

WHEN we build, let us think
that we build forever. Let
it not be for present delight nor
for present use alone. Let it be
such work as our descendants
will thank us for; and let us
think, as we lay stone on stone,
that a time is to come when
those stones will be held sacred
because our hands have touched
them, and that men will say, as
they look upon the labor and
wrought substance of them, "See!
This our father did for us."

—*John Ruskin.*

"BY HAMMER AND HAND ALL THINGS DO STAND"

AUDELS MASONS AND BUILDERS GUIDE #3

A PRACTICAL ILLUSTRATED TRADE ASSISTANT

^{ON}
MODERN CONSTRUCTION

FOR BRICKLAYERS-STONE MASONS
CEMENT WORKERS-PLASTERERS
AND TILE SETTERS

EXPLAINING IN PRACTICAL, CONCISE LANGUAGE
AND BY WELL DONE ILLUSTRATIONS, DIAGRAMS
CHARTS, GRAPHS AND PICTURES, PRINCIPLES
ADVANCES, SHORT CUTS-BASED ON MODERN
PRACTICE - INCLUDING INSTRUCTIONS ON HOW
TO FIGURE AND CALCULATE VARIOUS JOBS

BY

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Foreword

"The Audel's Guides to the Building Trades" are a practical series of educators on the various branches of Modern Building Construction and are dedicated to Master Builders and their Associates.

These Guides are designed to give technical trade information in concise, accurate, plain language.

The Guides illustrate the hows and whys, short cuts, modern ways and methods of the foundation principles of the art.

Each book in the series is fully illustrated and indexed for readiest form of reference and study.

The Guides will speak for themselves—and help to increase the reader's knowledge and skill in the Building Trades.

—Publishers.

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CHAPTER 86

Concrete

Although generally considered to be a discovery of the last century, concrete dates back to the Roman period. Concrete consists of two *aggregates* or hard materials and a binder, thoroughly mixed together with water. In drying, it becomes a hard mass like stone. This hardening property is called *setting*.

Binders

The various cementing materials employed in the making of concrete may be classed as:

1. Common lime
2. Hydraulic lime
3. Natural cement
4. Hydraulic cement
5. Puzzolan

They are classed as *hydraulic* and *non-hydraulic* according as they will, or will not set under water. With respect to this feature Prof. Hool classifies them as follows:

1. Hydraulic
 - a. Hydraulic lime
 - b. Puzzolan cement
 - c. Natural cement
 - d. Portland cement

2. Non-hydraulic

- a. Gypsum plasters
- b. Common lime

Common Lime.—When limestone composed of nearly pure carbonate of lime is burned, the resulting clinker, known as quick lime possesses the property of breaking up, or *slaking*, upon being treated with a sufficient quantity of water.

The slaking is accompanied with evolution of heat and a considerable increase of volume, forming a paste of lime hydrate or calcium hydroxide known as *lime putty*, or on dilution with water, as *cream of lime*.

The slaked lime possesses the property, when mixed to a paste with water and allowed to stand in the air, of hardening and adhering to any surface with which it may be in contact, it hardens on drying. When lime is nearly pure and its activity very great it is known as *fat lime*. When more or less impurities are present, it is not so active and is known as *poor lime*.

When quick lime is slaked at the place of manufacture and marketed in the form of a dry powder it is known as *hydrated lime*. The advantage of lime in this form is that it can be mixed with sand more easily than can lime paste made by slaking quick lime at the place of work.

There are three methods of slaking lime known as:

- 1. Drowning
- 2. Immersion
- 3. Sprinkling

Drowning Method.—The lime is usually spread out in a layer 6 or 8 ins. deep, in a mixing box, the water poured over it and allowed to stand, giving sufficient time for all of the lumps to be reduced. Sometimes in the case of poor lime this operation requires several days.

The amount of water used should be two or three times the volume of the lime—no more than is necessary. Add all the water at once, as the addition of water after the hydration is in progress causes a lowering of temperature and checks the slaking. The lime should be covered after adding water and should not be stirred until the slaking is completed. Cover by spreading a layer of sand, the latter being afterwards mixed with the lime.

Immersion Method.—Suspend the lime in baskets and immerse in water for a brief period to permit absorption of the necessary water, after which remove from the water and cover until slaking is completed and the lime falls to pieces.

Sprinkling Method.—Place the lime in heaps and sprinkle with the necessary quantity of water, then cover with sand and allow to stand.

Common lime is generally used in making mortar mixed with sand. Lime should be slaked several days before use to insure complete reduction of the lime.

Tests for Quick Lime.—When common or quick lime is old, or has been exposed to the air it absorbs both moisture and carbonic acid, thus rendering it less active, the portion combined with the carbonic acid being inert.

To test quicklime immerse a lump in water for a minute, then place it in a dish and if it be in good condition it will swell, crack and disintegrate with a rise of temperature.

Hydraulic Lime.—When the limestone contains from 10 to 20% of silica or clay mixed with the carbonate of lime, the material resulting from the burning is known as *hydraulic lime*. This clinker will slake when treated with water like common lime, but with reduced activity. The slaked lime thus obtained possesses the further property, when mixed with water to a

paste, of *hardening under water* and without contact with the air.

The slaking does not sensibly increase the volume and the hydraulic properties are due to the combination of calcium with silica contained in the limestone as an impurity, forming calcium silicate. It is the universal practice to slake the lime at the place of manufacture on account of the better results obtained.

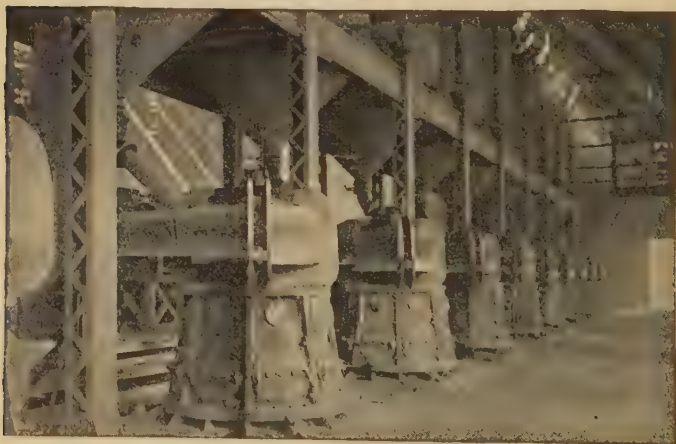


FIG. 4,870.—Interior Atlas Portland cement mill showing grinders.

NOTE.—*Grappier cement* is a by-product in the manufacture of hydraulic lime, produced by grinding the lumps of underburned and overburned material which do not slake, it possesses properties similar to those of hydraulic lime.

NOTE.—*Hydraulic lime* is not manufactured in the United States on account of the abundance of raw materials suitable for the manufacture of Portland cement, with which hydraulic lime cannot compete as a structural material. A number of hydraulic limes and grappier cements are marketed as "non-staining cements," because they do not stain masonry. For this reason a considerable amount of this cementing material is annually imported from Europe for purposes of architectural decoration.

Natural Cement.—As its name implies is made from a rock occurring in nature which had the combination of clay and limestone (orgillaceous limestone). Its composition varies greatly and because of its relatively low strength is only adapted to light duty work where mass and weight, rather than early strength are essential, as in dams, abutments, etc. For such work it is useful and cheap.



FIG. 4,871.—Interior Atlas Portland cement mill showing revolving tubes. The cylinder of these kilns are lined with very hard material, either iron or a specially hard natural stone and is partly filled with flint pebbles which are also extremely hard. When the partly ground rock is fed into the revolving tubes the pebbles are constantly rolling over and falling upon each other, so that the rock, being relatively softer, is pulverized by this grinding action. The rock passes slowly through the cylinder and when it reaches the discharge end is pulverized to extreme fineness.

Portland Cement.—It should be carefully noted that the term “Portland” is not a brand name but is a descriptive term, used because the first Portland cement was about the same

color as the famous limestone quarried on the Island of Portland. Today there are many brands of "Portland" cement manufactured in the United States. They vary just as different brands of flour or any other product vary. Accordingly in ordering Portland cement always specify which brand is desired, as for instance, Atlas Portland cement. Since Portland cement is manufactured instead of being made on the job, the proportion of its component parts is always uniform.



FIG. 4.872 Interior Atlas Portland cement mill showing bins. The cement is delivered from the storage bins to the packing house by conveyors, and feeds down through hoppers and automatic weighing machines. These give just the right quantity into each bag.

The various manufacturers have set standards for this work and adhere to them closely.

Portland cement is a chemical compound. It is manufactured from a mixture of two materials, one a *limestone* or a softer

material like chalk, which is nearly pure lime; and second, *shale*, which is like clay, or else clay itself. Portland cement can be manufactured anywhere that these ingredients are found, but it cannot be manufactured without the one material which is largely limestone, and the other material which is largely clay. The two materials must be mixed in exact proportions, determined by tests; the proportions being changed as often as necessary to allow for any variation in the chemical composition of the materials.

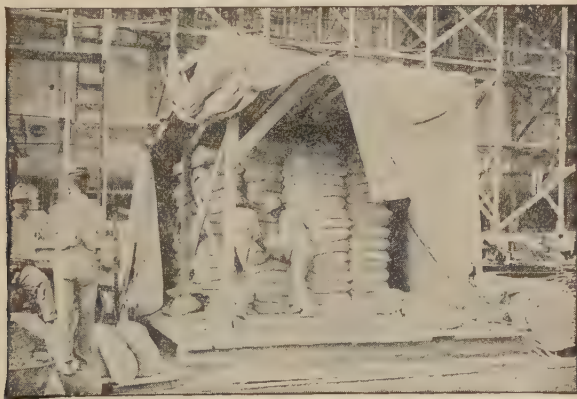


FIG. 4,873.—Method of protecting cement at mixer. Capacity about 250 bags. Roof of slabs and tar paper; canvas sides. Note flow raised off ground on mud sills.

To manufacture Portland cement the raw materials are quarried, crushed and pulverized, mixed in the proper

NOTE.—Portland cement is of modern origin. Joseph Aspdin of Leeds, England, took out a patent under date of December 15th, 1824, for the manufacture of Portland cement. It was so called because it resembled in color a well-known limestone quarried on the Island of Portland, which was then considered the hardest stone known. The manufacture of Portland cement was begun in 1825, but the progress was slow until about 1850, when, through improved methods, and general recognition of its merits as a building material, its commercial success was assured. About this time the manufacture of Portland cement was taken up by the French and Germans and by reason of their more scientific methods, both the method of manufacture and the quality of the finished product was greatly improved. The first German Portland cement works were built in Stettin in 1855.

proportions, and the pulverized raw materials of the correct chemical composition are then fed into rotary kilns,* where the mixture is burned to what is known as cement clinker.

Aggregates

By definition an aggregate is *the hard material, such as sand, gravel, stone, etc., that is mixed with cement and water to make concrete*. Aggregates are of two kinds:

*NOTE.—A *rotary kiln* is a steel cylinder 6 to 12 ft. in diameter and from 60 to 250 ft. in length. It is continuous in operation. The raw material is fed into one end and by reason of the inclined position of the kiln and its rotary motion, the material is passed into the lower end and discharged. During the passage of this raw material from one end of the kiln to the other, perfect calcination is obtained by means of an air blast, carrying powdered coal, the coal being set on fire as it enters the kiln. The clinker resulting from the burning of the raw material in this way is then cooled and pulverized and becomes the Portland cement of commerce.

NOTE.—*In the Lehigh Valley*, Pennsylvania, where a substantial proportion of the entire output of the country is manufactured, there are extensive natural deposits of what is known as cement rock, which contain the ingredients needed in practically the proper proportions for the manufacture of Portland cement.

NOTE.—*In the early days* in Germany and England, as well as in the United States, Portland cement was burned in dome kilns, much like those used for burning lime, the mixture in various stages being put into these kilns with alternate layers of coal or coke. The output of such a kiln was seldom more than 100 barrels a day. This process was continued until the early nineties, when the Atlas Portland Cement Company began experimenting with a steel cylindrical tube, known as the rotary kiln. It was rapidly developed by this Company and is being used today for calcining Portland cement in every mill in the United States and is gradually being adopted in Germany and England. These rotary kilns produce from 500 to 3,000 barrels per day, according to their size. More than anything else they have been instrumental in reducing the cost of manufacture to such an extent as to make Portland cement an economical building material.

NOTE.—*Portland cement* comes from the mill packed in cloth or paper bags containing approximately a cu. ft. and weighing 44 lbs. A barrel contains 4 cu. ft. and weighs 376 lbs. In storing, the cement should be kept dry, away from dampness. It should accordingly not be left on the ground as the latter is likely to be moist. When the cement once becomes wet and has hardened it cannot be used. The weight of the cement itself in the bag, or of one bag upon another as it is piled in a car or storage shed, may make it hard or lumpy. Such lumps or hardening do not affect the quality of the cement or its power to set. They break up in mixing. To determine if a lump be due to the pressure caking, see if it will crumble when it is pinched between the fingers. If not, it should be rejected as its cementing value has been destroyed.

NOTE.—When Portland cement once begins to set, the operation of setting must be continuous and uninterrupted, or the result will not be satisfactory. To secure what is called the proper curing of concrete, moisture must be supplied at the time it is taking its set, and all this time the mass of the concrete must not be disturbed.

1. Fine
2. Coarse

A *fine aggregate* is one of the particles of which will pass through a screen with $\frac{1}{4}$ in. openings. For fine aggregate, the material commonly used is sand or fine quarry screenings of stone.

A *coarse aggregate* is one of the particles of which will *not* go through a $\frac{1}{4}$ in. screen and they are usually not larger than $2\frac{1}{2}$ ins. Gravel or broken stone is the most common material for coarse aggregates. Sometimes pebbles are used.

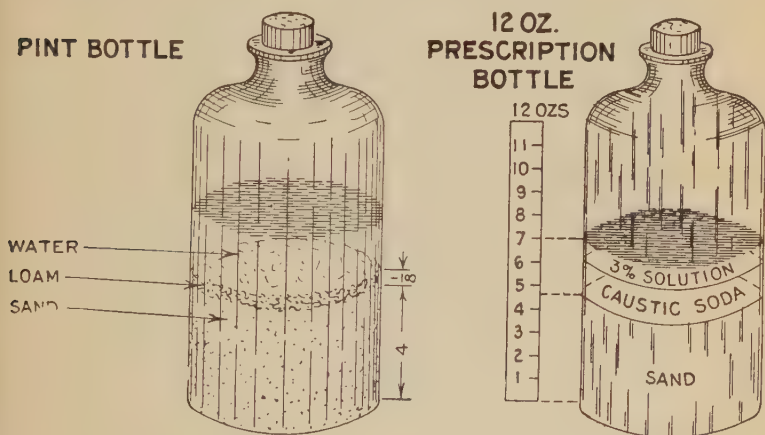


FIG. 4,874.—Test for loam. *To determine amount of loam* use a pint bottle as shown and put in 4 ins. of sand, then fill the bottle almost full of water. Shake thoroughly and allow to settle over night. The loam and fine material will settle on the top and the thickness of this layer should not be over $\frac{1}{8}$ ins.; if more, the sand should be washed.

FIG. 4,875.—Simple field method of testing sand for organic impurities. Place 4 in. of sand in the 12 oz. prescription bottle and pour in a 3% solution of sodium hydroxide until it stands $7\frac{1}{2}$ in. high in the bottle. Shake thoroughly and leave over night. If the liquid be darker than a straw color, look for another sand bank. If the liquid be clear, or only slightly straw color, see if there be more than $\frac{1}{4}$ in. of loam. If so it can probably be used by washing.

In selecting an aggregate it should be remembered that *a concrete cannot be harder than its aggregate*. Thus if cinders or broken soft brick be used, the concrete will be porous and weak like the aggregate. For exposed work avoid moisture absorbing aggregates.

Sand (Fine Aggregate).—By definition sand is clean rock particles, free from loam, clay or other foreign substance, varying in size from fine to those that just barely pass through a screen with $\frac{1}{4}$ in. meshes (4 meshes per linear inch; 16 meshes per sq. in.).

It is important that the sand should be a mixture of fine and coarse particles, more coarse than fine. There must be some

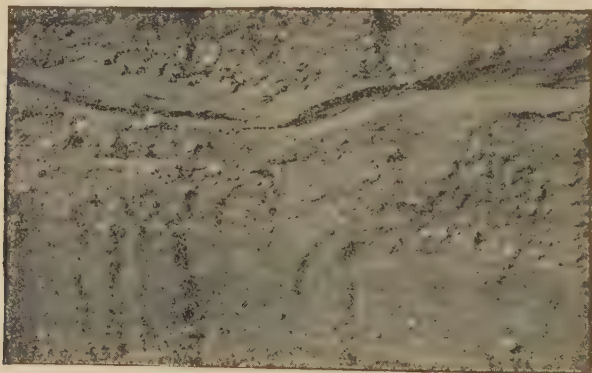


FIG. 4,876.—Typical sand bank containing fine and coarse material, there being too great a proportion of sand to gravel for use as it is. In bank run gravel the percentage of sand is usually higher than that required in a correctly proportioned mixture and is liable to vary greatly. Such material should be screened through a $\frac{1}{4}$ mesh screen; the sand and pebbles thus separated can then be proportioned in the correct amounts. Washing and screening at the same time may be accomplished by using the device shown in figs. 4,880 and 4,881.

fine particles because these smaller particles fit about and between the coarse particles, filling in the empty spaces between them. Figs. 4,877 to 4,879 show fine, graded, and coarse sand in actual sizes. The graded sand in the center is best because it contains both fine and coarse particles.

The sand must be both

1. Clean, and
2. Hard

It is the general impression that the sand should be "sharp." The particles

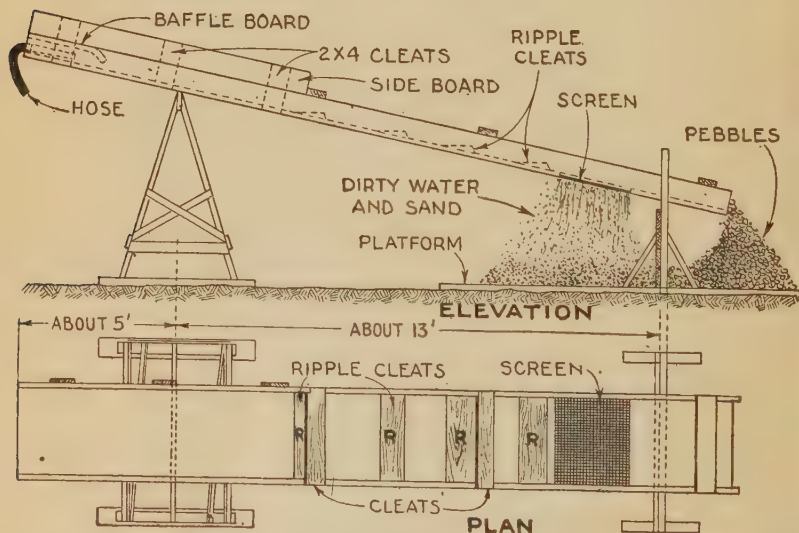


Figs. 4,877 to 4,879.—Various sands for concrete. Fig. 4,877, all fine sand (actual size) passing 30 mesh sieve, but retained on 50 mesh sieve, 50% is voids; fig. 4,878, well graded sand (actual size) consisting of 6 mesh to 50 mesh sand mixed in uniform proportions, only 42% voids; fig. 4,879, all coarse sand (actual size) passing 6 mesh, but retained on 8 mesh, 53% of this is voids.

need not be angular but should be clean and hard. In digging sand from a bank, be careful to take off all the top soil first, and then there will be no chance of loam sliding into the pit and mingling with the sand.

NOTE.—How to test sand. Take samples from different parts of the sand bank. With each sample make up some concrete by mixing three measures of sand and one of cement with the necessary water. Put the concrete in a tin pail and set aside for a few days. Then break it and see if it be strong enough.

Gravel and Crushed Stone (Coarse Aggregate).—As distinguished from the fine aggregate, coarse aggregate is defined as made up of *particles larger than $\frac{1}{4}$ in.*, the largest size fine aggregate particle being $\frac{1}{4}$ in. Coarse aggregate should be clean and free from impurities and to obtain this condition it should be washed the same as fine aggregate. The largest



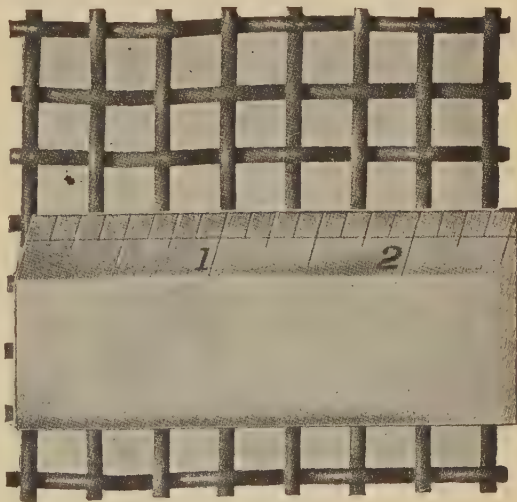
FIGS. 4,880 and 4,881.—Inclined trough for washing sand. The trough has a fine screen on the bottom (size of mosquito netting). *In washing*, one man shovels the sand on the upper end of the trough while another man washes it down the incline by pouring water on it. When the sand and water come to the screen the dirty water drains through and leaves the clean sand ready for use. Washing sand by wetting the pile with a hose is wrong as it transfers the dirt to the lower part of the pile.

particle of coarse aggregate should not be more than $2\frac{1}{2}$ ins. in diameter at the largest part for ordinary construction. A rule for maximum size is as follows:

Rule.—*Don't use any pebble or piece of broken stone if its greatest dimension be more than $\frac{1}{2}$ the thickness of the concrete being placed.* The coarse aggregate should be graded from small to large.

Figs. 4,883 and 4,885 show small and large particles and fig. 4,884, graded particles. Bank run gravel usually contains such varying amounts

FIG. 4,882. — Section of wire screen illustrating the term *mesh*. The term mesh in wire netting denotes the number of openings in either direction per linear inch, measured from center to center of parallel wires as shown. Many compare "mesh" with "space" or opening on account of which errors are made in ordering. Many users of wire cloth have the idea that it can only be manufactured in even meshes or even number of holes per linear inch, such as 3, 4 or 6 mesh. This impression, however, is not correct as Wire Cloth can be woven in odd or fractional meshes as well as full or even meshes. — *Buffalo Wire Works.*



NOTE.—*Odd methods of weaving.* 1. *The Dutch weave* has been found indispensable for filter purposes for beside having great tensile strength, it also possesses the desired capacity. If woven twilled it combines with these qualities that of pliability for forming purposes. 2. *Double and triple warp* are used almost exclusively in the making of the finer long meshes, the greater number of wires in the warp possessing a greater hold on the filling wires thus producing a fabric which will retain to a greater extent the exact mesh originally woven, a feature which would not be possible were a single wire used in the warp. This method also tends to greater flexibility of the warp making the fabric more adaptable for conveyor apron use. 3. *The twist warp* can be furnished in the coarser meshes which of course perform heavier service, thus requiring additional warp strength. It is also adaptable where the filling wires are required of about the same size or diameter or even lighter (and more closely woven) than the warp. 4. *Extra crimp* denotes an intermediate crimp between the meshes, and differs materially from plain weave. 5. *Cabled weave* provides possibly the most flexible texture capable of withstanding constant bending. 6. *Double weave* indicates a cloth with a double flat laid warp as well as a double filling. 7. *Rolled wire cloth.* While this term has no particular bearing on the manner of weaving, it more fully refers to the style of finish. Rolling is possible in very nearly all cases, except of course in the very fine meshes.



Figs. 4,883 to 4,885.—Various gravels (coarse aggregate). Fig. 4,883, all small gravel (actual size), particles between $\frac{1}{4}$ and $\frac{3}{4}$ in. in diameter, 42% is voids; fig. 4,884, well graded gravel (actual size), particles from $\frac{1}{4}$ to 1 in. in uniform proportions, 38% voids, being a mixture of small and large gravels, fig. 4,885, all large gravel (actual size) particles between $\frac{3}{4}$ and 1 in., 49% voids.

of fine and coarse aggregates that it should be screened before using, separating the fine aggregate from the coarse aggregate and remixing in proper proportions. Washing is easily done especially if the gravel bank be right at the site of the work.

Points on Choosing Aggregates.—To properly determine what aggregates should be used, the rules here given should be followed:

1. Sand must be coarse, hard and clean, with particles graded from fine to $\frac{1}{4}$ in. diameter, with the large size predominating.
2. The largest dimensions of the stones in the coarse aggregate should not be more than $\frac{1}{2}$ the thickness of the wall or slab of concrete.
3. All aggregates must be free from vegetable matter, dirt or other foreign substances.
4. To use bank run gravel, separate the sand from the stone and pebbles by screening through a $\frac{1}{4}$ in. screen.
5. For fence posts and other small concrete units, the fragments of coarse aggregate (crushed stone or gravel) should be $\frac{1}{4}$ to $\frac{1}{2}$ in. in diameter. For larger construction the size may range from $1\frac{1}{4}$ in. to $2\frac{1}{2}$ ins.
6. The largest dimensions of the stones in the coarse aggregate should not be more than $\frac{1}{2}$ the thickness of the wall or slab of concrete.

Water.—Only clean pure water should be used in mixing concrete; it must be free from alkali, acid or any impurity. Sea water should not be used. Water that is fit to drink is suitable.

Kinds of Concrete.—To meet the varied requirements met with in construction different kinds of concrete are used and which may be classified

1. With respect to the binder, as:

NOTE.—*Use of large stones in mass concrete.* In mass work, such as bridge abutments, large stones 6 ins. or more in size are sometimes used to save on the quantity of concrete. The concrete is mixed and placed in the regular way, and the stones are then imbedded in it one at a time. There should be at least six ins. of concrete between the stones and the forms. Not over 30% of the mass should consist of such large stones.

NOTE.—*Cinder concrete.* When cinders are used as an aggregate the mixture is called cinder concrete. The cinders should be hard and should not contain any fine ash; they should be thoroughly wetted at least a day before using to slake out any free lime and neutralize the effect of any sulphur present. Household ashes should not be used. Cinder concrete is suitable for cellar walls, for dwelling houses or light buildings, for floors that are not designed for carrying heavy. Cinder concrete is cheap and light in weight. It is ordinarily made in the proportion of one part of cement to five parts of cinders.

NOTE.—*Slag concrete.* Slag is a hard material although porous. It has high compressive strength and is suitable as an aggregate in mass concrete. It should contain practically no sulphur content.

- a. Lime
- b. Asphalt
- c. Cement

2. With respect to the coarse aggregate, as:

- a. Gravel
- b. Stone
- c. Cinder
- d. Slag, etc.

Of the various kinds of concrete cement concrete is the most important. The use of any particular kind of concrete depends upon the location, kind of structure, the required strength, and climatic conditions.

Lime Concrete.—This kind of concrete is made by mixing unslaked, or hot fresh ground lime together with four times its weight of gravel and twice its weight of sharp sand, upon a stone, brick or wooden floor. The mixture is raked and spread twice over to dry, and when shoveled into a heap for the third time it should be wetted with water sprinkled from a hose.

Add just enough water to slake the lime and cause the compound to adhere in a pasty mass, about one U. S. gallon per cu. ft. generally being enough. The mass should be well raked and turned over with hoes and spades while the water is being added.

Ground lime is better for use in the mixture but should a hydraulic lime be used in its lump form, it is preferable to leave it to slake for two or three days well covered up by sand to retain the heat.

***Asphalt Concrete.**—This is made with Trinidad asphaltum. It is recommended to melt 4 parts of mineral pitch (from petroleum), in a cauldron, adding first 27 parts by weight of asphaltum broken small, next 1 part of resin oil, and stirring in

2 parts of sharp sand. When the whole is thoroughly incorporated and fluid, it is termed *asphalt mortar* and may be used as such. To form into concrete, it is mixed while melted with nine-elevenths of its weight in broken stone.

Coal tar asphalt is the term frequently applied in the United States to a mixture of slaked lime and gravel, to which is added the waste tar from gas works, commonly known as coal tar. Coal tar, chalk and gravel are also boiled together to give the requisite consistency; this is used as a substitute for the genuine article.

The derivative from petroleum is often termed *mineral pitch*, and serves as a waterproof paint, an anti-corrosive coating, and numerous other uses. The Trinidad asphalts are mixed while hot with sand or fine gravel for the purpose of lining tanks, forming paving, damp courses, roofing, etc.; or they may be used to impregnate paper or textile fabrics for similar purposes.

The French and Swiss rock, so largely used in London and Paris, requires no admixture, crumbling to powder under heat, in which condition it is spread and rolled, regaining the appearance of the original rock on cooling.

Cement Concrete.—Of the various kinds of cement used in cement concretes only Portland cement is used for important work. Since it is made scientifically it is uniform in quality resulting in dependable concrete. Cement concrete is usually made of cement, sand and gravel or stone as later explained in detail.

*NOTE —*Asphalt* is a name applied to three diverse allied substances: 1, the base or ultimate result of changes in those petroleum or natural hydro-carbons which do not contain paraffin; 2, natural deposits of asphaltum or bitumen found in the form of self-renewing lakes in Trinidad, W. I., Venezuela, and elsewhere; 3, limestone rock impregnated with 8 to 20% of bitumen, as found in the Val de Travers in Switzerland.

Handling the Materials.—Proper methods of handling the materials on any particular job will materially reduce the cost of construction. In each case, the quantities to be handled, the areas over which they must be distributed, the facilities for procuring and receiving the raw materials, and the working space available must be considered and each case will present other conditions peculiar to itself.

After reaching the place of work, the materials are carried to the bins by carts, wheel barrows, small cars, dredge buckets,



FIG. 4,886.—Stone and sand pile with runway to mixer.

or belt or chain conveyors. From the bins on large jobs they are usually carried by gravity through hoppers to the mixer.

Cement is usually stored in sheds or other warehouses and is handled separately from sand and aggregates in bags or barrels, often by means of chain conveyors. The work is facilitated by having the cars, barrows, buckets, of known capacity, so that they may serve as measures in proportioning the materials.

The cement is usually measured separately by counting the bags or barrels employed. Usually a measuring platform is placed directly over the mixer.

For maximum output there should be two sets of measuring hoppers, one to be dumping into the mixer while the other is filling. The aggregate may be washed in a revolving cylindrical screen by a jet of water under high

pressure. Cement must be kept off the ground no matter what arrangements are made for its storage.

In order to reduce wheel barrow runs, the sand and stone piles should be located close to the mixer since more stone is used than sand, the stone pile should be located nearest to the mixer. Where there is plenty of room the sand and stone is stored in low piles just as dumped from the wagons.

Placing and Depositing Concrete.—In its plastic form after mixing, the concrete must be placed in forms or moulds to shape it to the required form. It should be placed at the longest, within 30 minutes.

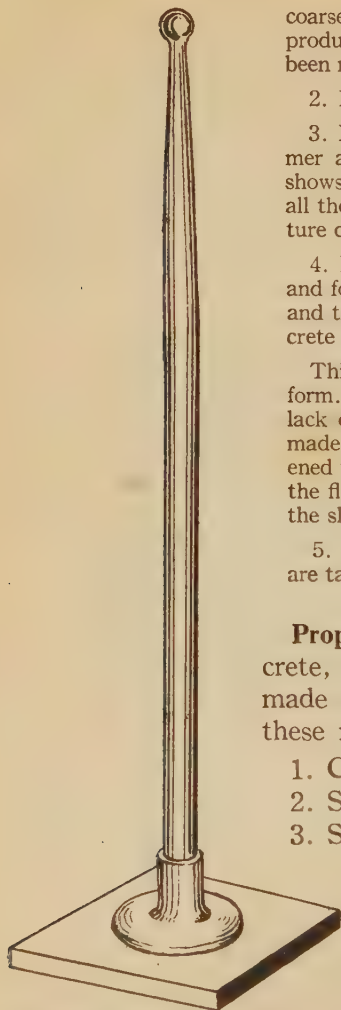


FIG. 4,887.—Concrete mixer charged by elevating skip into which the barrows dump. Note that this means that sand and stone are wheeled on a level.

Methods of placing vary with working conditions and the nature of the construction but the following rules will be found helpful in general construction:

1. Concrete batches should be spaded into place rather than tamped.

A convenient tool for spading is an old garden spade, or a hoe which has been straightened out so that the blade is in line with the handle. Special spading tools are also made with perforations in the blades which assist to bring the sand cement mortar against form faces while holding back the



coarse particles in the concrete and in this way produce a smooth surface finish when forms have been removed.

2. Place concrete layers about 6 ins. thick.

3. Pack it down lightly with a tamper or rammer as shown in fig. 4,888. Do this until water shows on top of the concrete and mortar covers all the stones from sight. This makes the mixture dense.

4. For a smooth surface, work a spade back and forth and up and down between the concrete and the form on the side where the finished concrete will be exposed to view.

This brings the coating of mortar next to the form. Where a spade cannot be used, because of lack of room, substitute a thin wooden paddle made from a board that is 1 in. by 4 ins., sharpened to a chisel edge on one side of the end. Keep the flat side of the paddle next to the form and the sharpened side turned in.

5. The drier the mixture, the more important are tamping and spading.

Proportioning the Materials.—Concrete, as has already been explained is made up of a binder and two aggregates, these materials being usually

1. Cement
2. Sand
3. Stone

The cement is the smallest quantity in the mixture and is taken as a unit of measurement. It comes in bags containing

FIG. 4,888.—Tamper or tool used to pack concrete. *It has a wooden handle with metal block at end.*

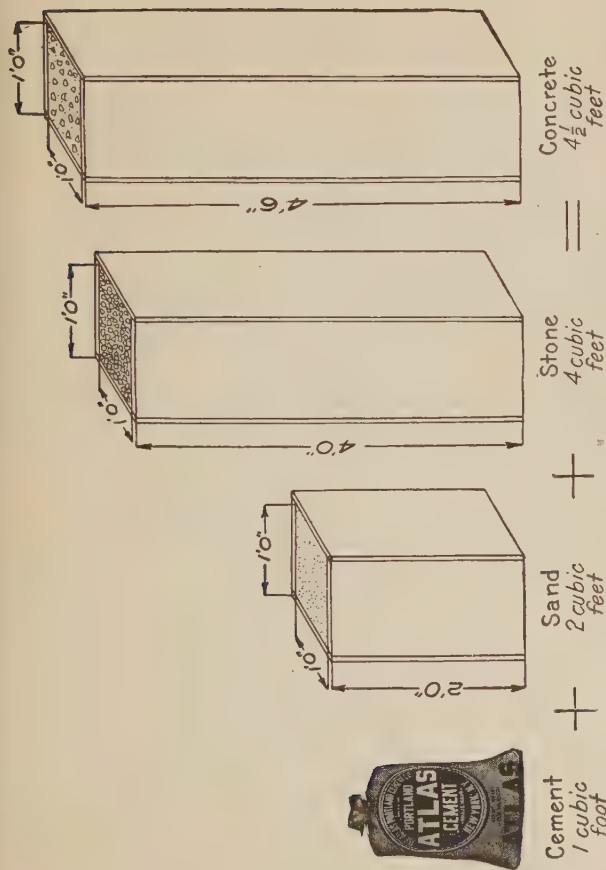


FIG. 4,889 to 4,892.—1 : 2 : 4 proportion for cement showing relative volumes of the three materials and resulting volume of concrete.

approximately 1 cu. ft. The proportion of the mixture is stated in terms of the cement unit, thus:

1 : 2 : 4

means, a mixture of concrete made up of:

- 1 part of cement
- 2 parts of sand
- 4 parts of stone

Thus in making up such a mixture, for every bag of cement, mix 2 cu. ft. of sand and 4 cu. ft. of stone as illustrated in figs. 4,889 to 4,892.

In mixing concrete *satisfactory results are obtained only by proper proportioning.*

The object of proportioning is to make a sufficiently dense concrete mixture. Sand or gravel or crushed stone alone, have between their particles empty spaces called "voids." To make dense concrete the cement, sand and stone must be proportioned so that the voids in the coarse aggregate are filled with the finer particles of sand and cement, and so that the voids in the sand are filled and bound together with the particles of cement.

This is the reason that the 7 cu. ft. of material shown in fig. 4,889, when mixed make only $4\frac{1}{2}$ cu. ft. of concrete instead of 7 cu. ft. This point should be remembered in order to avoid mistakes in estimating the quantity of materials to make a given quantity of concrete.

The following table shows this relation or shrinkage.

Volume of Concrete Mixtures

Proportions of Mixture			Volume of concrete
Cement	Sand	Gravel or stone	
1 bag	$1\frac{1}{2}$ cu. ft.	3 cu. ft.	$3\frac{1}{2}$ cu. ft.
1 "	2 "	3 "	$3\frac{9}{10}$ "
1 "	2 "	4 "	$4\frac{1}{2}$ "
1 "	$2\frac{1}{2}$ "	5 "	$5\frac{2}{5}$ "
1 "	3 "	5 "	$5\frac{4}{5}$ "

It is seen from the above table that the resulting volume of concrete is only a little more than the quantity of stone.

For almost all work twice as much gravel or stone must be

used as sand. Concrete mixtures are classed according to the degree of richness due to relative amount of cement used, as

1. Rich
2. Standard
3. Medium
4. Lean

Rich Mixture.—1 part cement, 2 parts sand, 3 parts coarse aggregate. Used for concrete roads and water proof structures.

Standard Mixture.—1 part cement, 2 parts sand, 4 parts coarse aggregate. Used for reinforced work floors, roofs, columns, arches, tanks, sewers, conduits, etc.

Medium Mixture.—1 part cement, $2\frac{1}{2}$ parts sand, 5 parts coarse aggregate. Used for foundations, walls, abutments, piers, etc.

Lean Mixture.—1 part cement, 3 parts sand, 6 parts coarse aggregate. Used for all mass concrete work, large foundations, backing for stone masonry, etc.

Mixing the Materials.—The object of mixing is that each grain of sand should be coated with cement and that each pebble or fragment of stone should be evenly distributed through the mass, water being included in the mixing in order that it may serve as a medium for forming a cement coating and cause the cement to set and harden on drying.

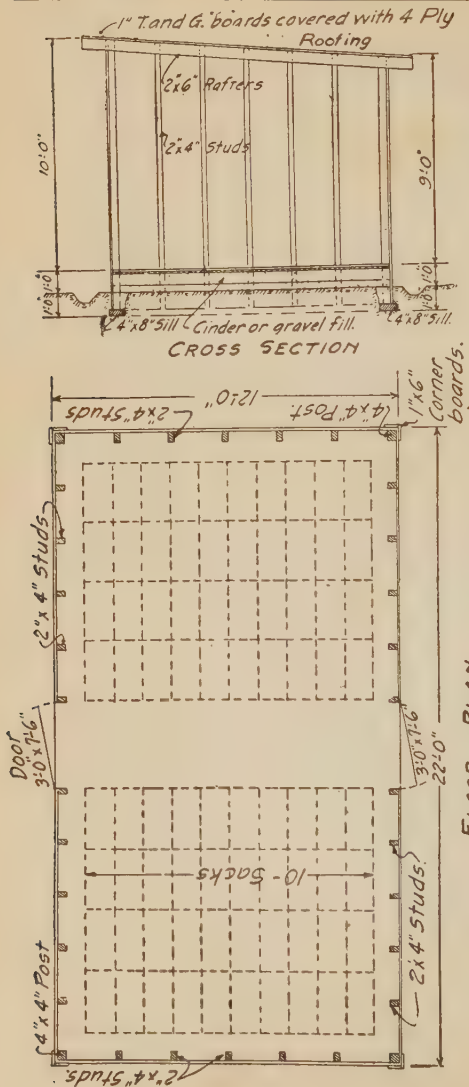
It is of greatest importance that the mixing be thorough otherwise the resulting concrete will not be homogeneous in character. Concrete should be mixed as near the place where it is to be used, and only when ready to use because it begins to set almost immediately after mixing.

There are two ways of mixing concrete known as:

1. Hand mixing
2. Machine mixing.

Hand mixing is unadvisable except on small jobs.

Hand Mixing.—In this method, a platform consisting of



FIGS. 4,893 to 4,895.—Details of inexpensive damp proof temporary cement storage building. The capacity of this building is one car load of cement, but may be increased by additions of similar sections. Note cinder fill around floor joists with 2 in. double wood floor with tar paper between. Small ditch around building provides for proper drainage and will help keep dry the ground or fill under building.

planks laid on the ground loose, or nailed together with cross strips is necessary.

The ground should be smooth so that the boards, if simply laid, will fit close together; with this primitive platform some cement will be lost through the cracks during the first mixing.

A permanent platform may be made using inch boards placed on 2×4 cross stringers spaced 2 ft. apart. The boards should

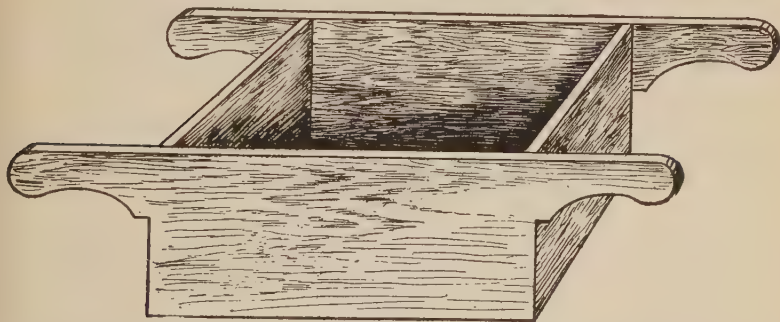


FIG. 4,896.—Box, or frame for measuring the materials in making concrete. *In size* the box should have a capacity of 1 cu. ft. It should have handles on the sides and no bottom as shown. The same materials are easily and accurately proportioned by means of this box. *In measuring*, place the box on the flat surface of the mixing platform, and fill with each material, level with the top as many times as called for by the formula. When filled it is easily lifted off by means of the handles at each corner, and no further tipping or moving is required.

be dressed on the top side so that shoveling and turning will be easy.

In hand mixing it is usual to mix the sand and cement dry, usually by turning with shovels two or three times, or until the mixture is of uniform color which indicates that each grain of sand is coated with cement. Water is then added and the mortar is mixed before the aggregate is added, or the aggregate,

may be spread over the dry mixed sand and cement, or these thrown upon the aggregate and the whole then wet and mixed by two or more turnings with shovels until the water is thoroughly mixed with the sand and cement.

In doing the actual mixing the Atlas Cement Co. recommend the following method:

1. Measure all materials accurately to get correct proportions. Make a measuring box to hold a cu. ft. as shown in fig. 4,896.

2. Wheel the sand to the mixing board, measure it and spread it about 4 ins. deep on the board.

3. Empty on the sand the correct amount of cement; according to the mixture desired. Spread the cement evenly over the sand.

4. Turn dry sand and cement over and over with a shovel or hoe until they are thoroughly mixed.

5. Spread out the mixture and empty on it the proper amount of coarse aggregate carefully measured. Mix this thoroughly.

6. Add $\frac{3}{4}$ of the required amount of water, say about $\frac{3}{4}$ of a gallon of each cu. ft. of concrete. Be careful to add the water slowly and evenly, mixing the whole mass at the same time.

7. Add more water wherever dry spots appear, until the whole mass has been turned or shoveled over three or four times.

8. Shovel the mixture into a compact mass and wheel away.

Proportioning the Water.—Excess water weakens concrete; an insufficient amount prevents thorough mixing. Accordingly, water should be measured with the same precision as the other materials. One pint more water than necessary in a one-bag batch decreases the strength and resistance to wear of concrete as much as if two or three pounds of cement were left out. Concrete hardens because of chemical reactions between cement and water.

The strength of concrete depends upon the relation between the volume of mixing water and volume of cement. As long as

Strength of Concrete

(For various proportions of water)

Gallons of water for one bag batch.....	5¾	6	6¼	6½	7	7½	8	9	10	12	15
28 days compressive strength lbs. per sq. in.....	2,770	2,600	2,400	2,250	1,950	1,670	1,470	1,100	830	480	200

Mixing Water Required for Concrete

(Approximate quantities)

Cement	Mixture		Water Required Gals. per sack of Cement	
	Aggregate			
	Fine	Coarse	Minimum	Maximum
1	1¼	2½	5	5½
1	1½	3	5½	6
1	2	3	5¾	6¼
1	2	4	6	6½
1	2½	5	7¼	7¾
1	3	6	8¼	8¾

the mixture is workable the less water used the stronger the cement.

The accompanying table shows the effect of water on the strength of the concrete.

Consistency of the Mixture.—The consistency to be used depends upon the nature of the work. For mass work, sidewalks and pavements

NOTE.—*The injurious effect of water* is especially noticeable in the case of concrete walls. Too much water brings a mixture of the flowing part of the cement and water to the surface and at the end of the day's work this forms a layer of white material known as *laitance*. This *laitance* prevents the proper bonding of more concrete placed thereon and constitutes a plane of weakness. It is especially injurious if it occur in tanks or dams, where water tight construction is necessary. When *laitance* forms it should always be removed by scraping before new concrete is placed. The approximate quantity of water required for usual conditions is given in the following table.

the concrete can be fairly stiff. For reinforced concrete floors, the consistency should be a little more plastic so that the concrete can be worked into place around the steel without difficulty.



FIG. 4,897 —Slump test. After the mould has been filled it is carefully withdrawn. The amount of *slump* or sagging down of the concrete indicates the consistency. **In testing** fill the form with the concrete, placing it in layers about 4 ins. deep and working it with a pointed metal rod ($\frac{1}{4}$ in. diameter and 21 ins. long), each layer being rodded exactly 30 times. Lift off the form immediately and measure the settlement in "slump" of the concrete as in fig. 4,898.

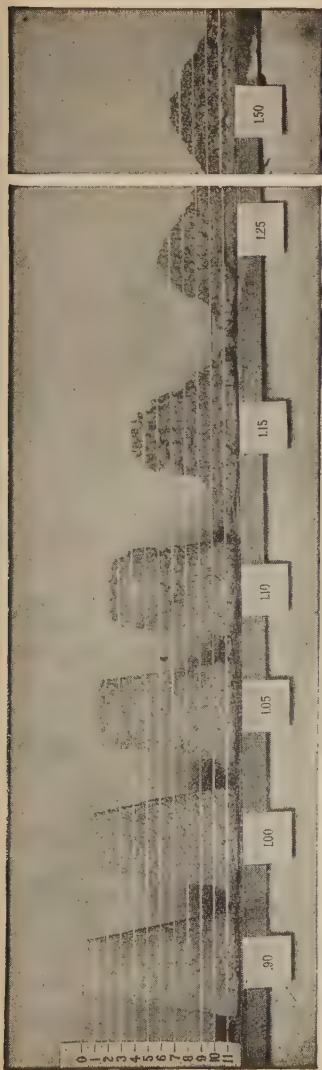


FIG. 4,898.—Test piles of concrete showing relation between consistency and slump. The tags on each pile indicate the relative consistency of the pile. The scale at the side shows the slump in inches.

For thin reinforced concrete walls the mixture must be even more plastic. For all work, however, the consistency should be as stiff as possible. Extremely wet mixture should never be used. Consistency is easily measured and regulated by the “slump test” shown in fig. 4,897. Through its use on the job the quantity of mixing water used in the concrete can be controlled fairly closely.

Concrete having a slump of $\frac{1}{2}$ to 1 in. will contain only a little more water than necessary for maximum strength, but will be too stiff for most construction work. Such concrete is said to have a relative consistency of 1.

Concrete containing 10 per cent more water is said to have a relative consistency of 1 and will give a slump of 3 to 4 ins.; 25 per cent more water gives a relative consistency of 1.25 with a slump of 6 to 7 ins. 50 per cent more water gives a relative consistency of 1.5 with a slump of 8 to 10 ins.

The following table shows the maximum recommended slumps:

Maximum Slump

Type of Concrete	Maximum Slump
Mortar for flow finish.....	2 ins.
Roads and pavements.....	
<i>a.</i> Hand finished.....	4 "
<i>b.</i> Machine finished.....	1 "
Mass concrete.....	2 "
Reinforced concrete.....	
<i>a.</i> Thin vertical sections.....	6 "
<i>b.</i> Heavy sections.....	2 "
<i>c.</i> Thin confined horizontal sections.....	8 "

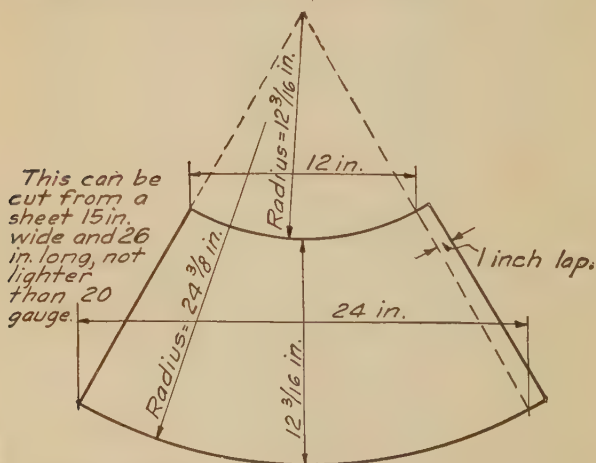


FIG. 4,899 —Diagram for cutting metal to make frustum of a cone used for the slump test.

Machine Mixing.—It is more economical on large jobs to mix concrete by machinery than by hand. There are a multiplicity of types of concrete mixers on the market, small and large, and some self-propelling. Buy only a batch mixer, that is, one with a revolving drum in which all the materials are put

together and which revolves until the mixing is completed. A full explanation of concrete mixers is given in the next chapter.

Water Tight Concrete.—When made from properly selected aggregates, combined with Portland cement in suitable proportions, when thoroughly mixed to the right consistency,



FIGS. 4,900 to 4,902.—Three typical consistencies of concrete mixture when poured. A guide for mixing concrete for different kinds of work. Fig. 4,900, *mushy consistency*—not to be used except for very thin walls or sections; fig. 4,901, *quaking consistency*—quakey or jelly like—the best consistency for ordinary work; fig. 4,902, *dry consistency*—like damp earth. This consistency must be thoroughly damped or packed when deposited. Used in making concrete blocks.

carefully placed, and adequately protected during early hardening, concrete will be water tight under all ordinary conditions.

Water tight concrete means good concrete. A few fundamental principles of good construction should be carefully observed. These can be summarized as follows:

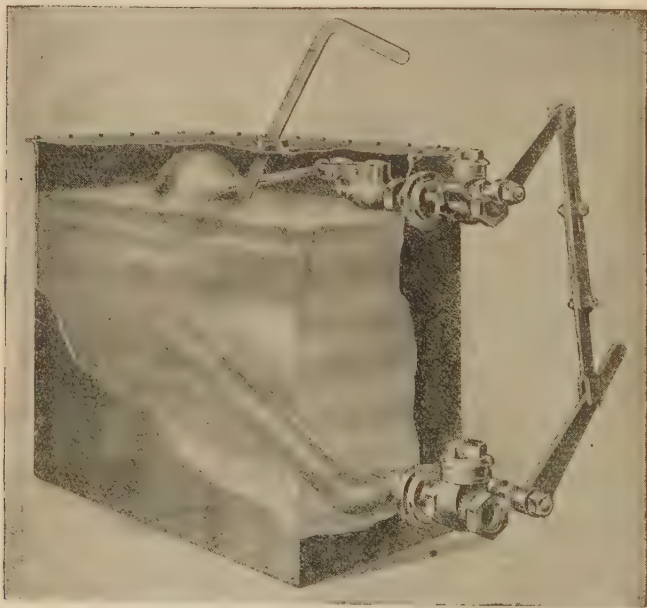


FIG. 4,903.—Municipal automatic measuring tank for measuring the water for each batch. The supply can be varied according to requirements by raising or lowering the gauge rod projecting through top of tank.

1. All portions of the structure should be strong enough to resist the head of water, either internal or external, to which the concrete may be subjected.
2. Use clean, well graded aggregates.
3. Use a relatively rich mixture, a 1:2:3, or better 1:1½:3.

4. Use the minimum amount of mixing water that will give a workable, plastic consistency; not over 6 gallons per sack of cement.
5. Mix the concrete thoroughly, at least $1\frac{1}{2}$ minutes per batch mixer.
6. Place the concrete carefully in layers 6 to 12 inches deep, spading or rodding it thoroughly to prevent the formation of stone pockets or voids.

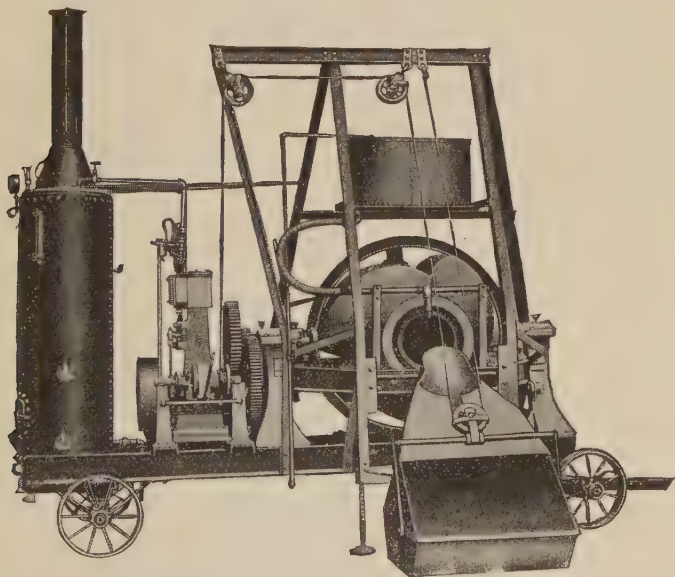


FIG. 4,904.—Clover leaf mixer, showing involute curved drum. *In operation*, the drum revolves counter clockwise. As the material is carried along it falls of its own weight when it reaches a certain point. In falling the material is doubled over several times each revolution.

NOTE.—*Water tight concrete.* In tests conducted by the U. S. Bureau of Standards, thin slabs of a lean (1:6) Portland cement mortar and $1:1\frac{1}{2}:2$ concrete were subjected to a water pressure of 60 pounds per square inch. This pressure is equivalent to a 138-foot head of water. Although water penetrated through $1\frac{3}{8}$ -inch limestone slabs in periods ranging from 20 seconds to 20 minutes, it took $3\frac{1}{2}$ hours for water to penetrate through a two-inch slab of 1:6 mortar, while at the end of 24 hours, when the test was terminated, the two-inch slab of $1:1\frac{1}{2}:2$ concrete was still dry. Hundreds of concrete tanks are being used for the storage of fuel oil, which is lighter than water, and these tanks are oil tight, and of course water tight. Concrete basements, pits, bridges, and tanks will also be water tight if proper care be taken in their construction. Experience and tests have shown that proper practice will make water tight concrete.

7. If possible place the concrete in one continuous operation to avoid construction joints. If placing be interrupted, be sure to get a good bond between the fresh concrete and that placed previously.

8. Keep the concrete warm and damp for the first ten days.

CHAPTER 87

Concrete Mixers

Concrete mixture is cement, sand, and gravel or broken stone, mixed with water. The quality of a concrete mixture is determined by

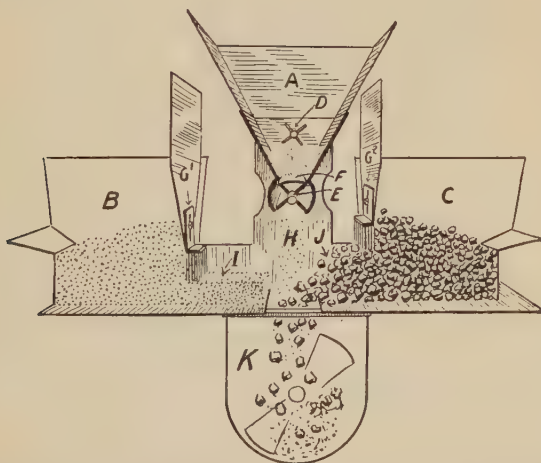
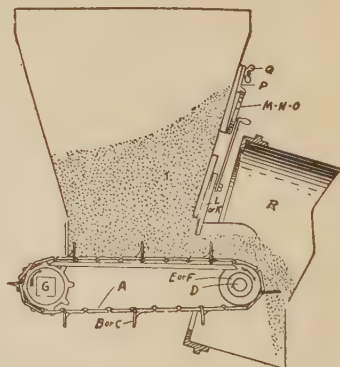
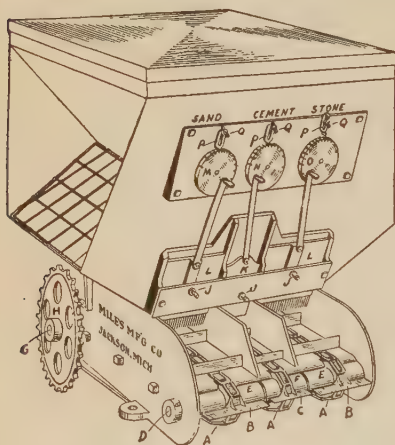


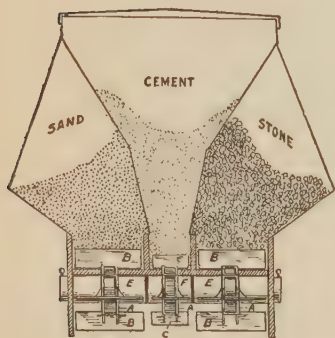
FIG. 4,905.—Grand charging hopper. *In operation*, as hoppers B and C, reciprocate backward and forward, the material that is thrown into hopper B, is forced toward the mixing trough at one move of the hopper, shoving charge I, off into the mixing trough and at the same time "striking off" charge J. At the next movement of the hopper, charge J, is shoved into the mixing trough and charge I, is "struck off." The amount of these charges is determined by the height of steel wire brushes G1 and G2, which are adjustable: The amount of the cement discharged is regulated by a steel slide which passes over the cement feed roll. This slide is drawn out certain distances for different proportions, allowing only the uncovered part of cement roll to fill and discharge. After slide is set for desired proportion it is locked in place by set screw so there is no possible chance for variation in the proportion. By discharging the cement and other materials at the same time we receive a good gravity mix before the material even reaches the mixing trough.

1. The quality and proportions of the materials composing it, and



FIGS. 4,906 to 4,908.—Miles three compartment charging hopper. *In operation*, cement enters through the center and sand, crushed rock, or gravel from either or both sides. A constant stream

of materials are fed simultaneously into the mixing drum, the mechanism being adjustable so that any proportion may be obtained. The feed is controlled by an individual clutch and may be stopped or started regardless of the rest of the machine. Often for various reasons, the shovellers stop for a minute or two. In such cases the feed is thrown out of gear by a clutch lever. Further if it be desired to empty the drum, the feed may be stopped while the balance of the mixer continues until the materials are all discharged. The materials are conveyed or forced into the mixing drum by three conveyor chains with scraper links. These conveyor chains are driven by three sprocket wheels, mounted on a square steel shaft, which prevents any possibility of their slipping and all are traveling at the same speed, and by the adjustments of the steel brushes and the fact that it can be fed from either or both sides, gives the machine a capacity up to one hundred yards in ten hours. The cam or eccentric proportioning discs



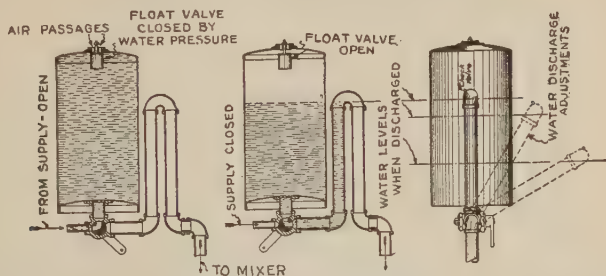
which are graduated and provided with a positive locking device. *The parts are:* A, chain, B, scraper links for sand; C, scraper links for cement; D, idle sprocket; E, idle sprocket for sand chain; F, idle sprocket for cement chain; G, square shaft; H, sprocket feed drive; J, adjustment for thickness of brushes; K, cement slide; L, brushes for sand or stone; M, proportioning cam for sand or gravel; N, proportioning cam for cement; O, proportioning cam for stone or sand; P, slotted slide for holding proportioning cam; Q, lock nut for double locking proportions; R, short section of mixing drum.

2. Its uniformity.

Hence, the best mixture depends not alone on the quality of material but upon the quality of the mixing.

To properly mix concrete, the elements must be successively subdivided and re-arranged in new relations toward each other. To keep the fine pieces from sifting to the bottom, a pouring action is necessary, combined with a horizontal endwise movement, averaging all parts of the batch.

The essential parts of a concrete mixer are:



FIGS. 4,909 to 4,911.—Lakewood automatic tank. **The water tank** is filled by attaching a hose to the one-inch pipe connection on the three way valve below, and pulling the operating handle down, when the tank will fill to the top and close automatically. By pushing the handle up, the connection from the supply hose is cut off and the discharge side of the valve is opened, allowing the water in the tank to flow into the mixer. The amount discharged from the tank into the mixer can be regulated by the loop of two inch pipe on the discharge side of the tank by placing this loop in a vertical position if a small amount of water be desired, and by placing the loop in a horizontal position when the full contents of the tank are desired. Any amount between the minimum and maximum can be discharged, by placing the loop at intermediate positions between the vertical and horizontal.

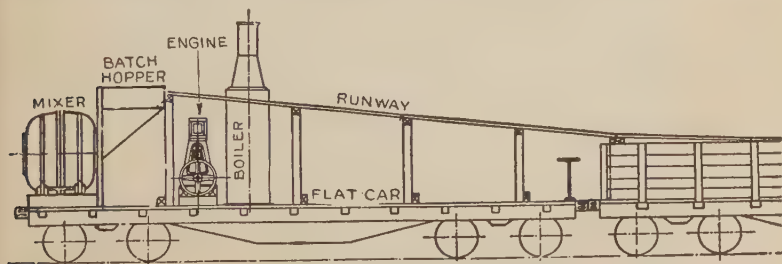


FIG. 4,912.—Milwaukee mixer with batch hopper, engine boiler and run ways. All mounted on a flat car, discharging over the end of the car.

1. Charging hopper;
2. Mixing drum;
3. Water tank;
4. Discharge device.

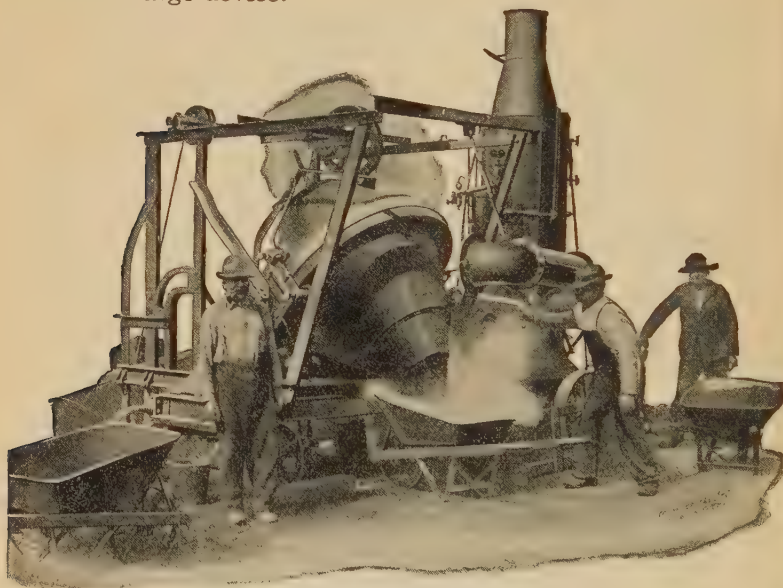


FIG. 4,913.—Smith tilting drum hot mixer on asphalt repair work. *In the hot type* of mixer a steam blower creates a forced draught from the boiler through the mixing drum. The gases enter the mixer at a temperature well above 600° Fahr. As the aggregate is sprayed from the blades, every surface is dried and heated by immediate contact with the hot fumes. The rapid motion of the particles prevents sooting or burning of the material. The bitumen is introduced after the drying process is complete, by means of the tank on the top of the skip. The output of the mixer varies with the size, character and condition of the aggregate and the temperature desired for the finished batch.

The Charging Hopper.—This should be not over 36 to 40 inches high, so as to be convenient for either shovel or wheel barrow charging. It should also be wide enough to receive the discharge of an ordinary concrete barrow, and have high wings to keep the gravel from spilling.

Mixing Drum.—The drum is usually cylindrical and rotates on bearings called trunnion rollers.

The tracks encircle the drum which bear upon the rollers, and support the drum as it turns. At the center is a circular rack to which power is applied through a pinion for driving the drum. At each end of the drum is a head having a central opening, one for charging and one for discharging. The general appearance of a mixing drum as described is shown in figs. 4,915 and 4,916.

Water Tank.—The water used in mixing concrete is usually placed in an elevated tank containing some device to regulate the flow.

On one type of tank, the amount of water desired is regulated by a float inside of the water tank. This float can be set by the contractor according

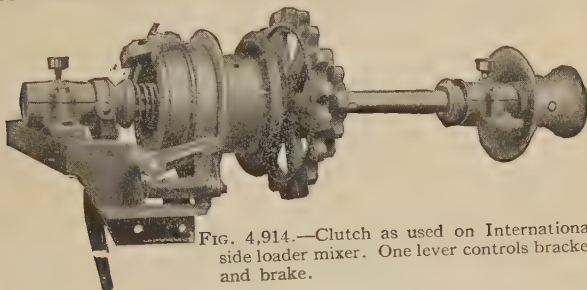


FIG. 4,914.—Clutch as used on International side loader mixer. One lever controls bracket and brake.

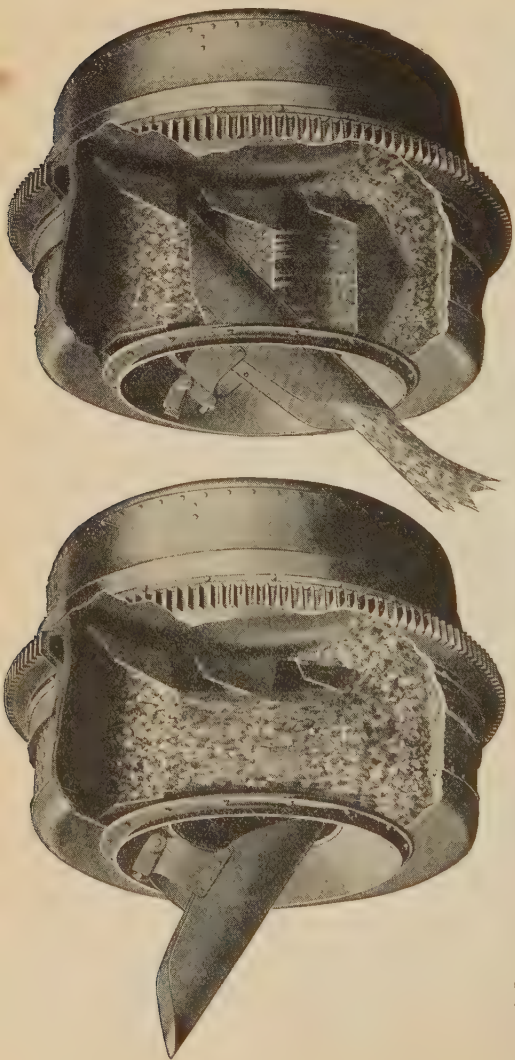
to the consistency of the batch he desires. By raising the float the flow of water is increased, and by lowering, decreased.

When the desired flow of water is secured, the float can be set and there will be no other adjustments necessary until the contractor wishes to change the consistency of his batch.

The construction of the water tank is very simple, consisting of the float, one check valve, one three way plug valve, and one hand lever by which it is operated.

Methods of Discharge.—The two general methods of removing the concrete mixture from the drum is

1. By tilting the drum
2. By inserting a chute



Figs. 4,915 and 4,916.—Detail of drum showing chute method of discharge. Fig. 4,915, chute in mixing position; fig. 4,916, chute in discharging position. When the chute is in discharging position the concrete is carried up by the buckets in the drum and dumped into the chute, which, being pitched at a great angle, delivers the material at a high speed.

Fig. 4,913 shows a mixer discharging by the first method. Figs. 4,915 and 4,916 illustrate the chute method of discharge.

Power Transmission.—On all mixers the engine furnishes power for turning the drum, and in many cases, provision is made to apply the power for loading and discharging the drum.

Figs. 4,920 and 4,923 show chain drives with countershaft for turning and loading the drum.

On the Smith mixer which has a tilting drum, the tilting motion is reversible, permitting discharge of any part of the batch. At the points of greatest travel, the clutches are automatically disengaged. The tilting action is controlled by a revolving screw and traveling nut.

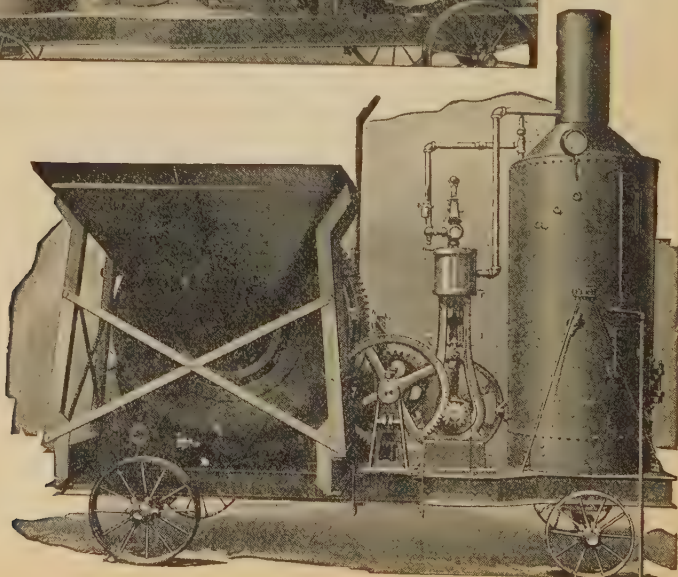
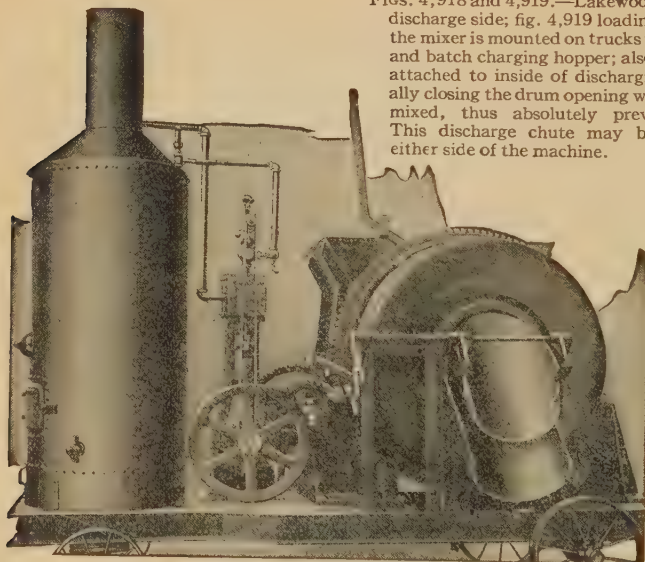


FIG. 4,917.—Jaeger mixer with automatic power loader. **Capacity** claimed to be nearly double that of a mixer without loader. **In operation**, while one batch is mixed, another is assembled, thus reducing operating cost. Time consumed: 40 seconds to mix; 10 seconds to discharge. **Specifications:** Drum 34" diameter, 30" deep, 21" opening. Capacity, 7 cu. ft. dry material. Drum always revolving, emptying all or part of batch as desired. Size over all 58" X 84". Height to charge 39". Engine 3 H.P. magneto equipped; engine house, 26 X 36 X 33, built of angles covered with sheet metal. Operated by quick acting hoist connected directly with engine. Mixer and loader controlled by one man from one position. Loader bucket ample for 7 cu. ft. batch. Trucks—rear wheels 24" diameter; steel axle 58" long; front wheels 20" diameter. Weight 2,400 lbs.

The Power Unit.—The conditions under which a concrete mixer is used are such that the power machinery must be very dependable, since usually it receives little or no care, being entrusted sometimes to an engineer of low grade.

Accordingly, the power outfit is of the simplest type, consisting of a slide valve engine and upright shell boiler designed to operate at about 80 lbs. pressure.

FIGS. 4,918 and 4,919.—Lakewood mixer Fig. 4,918 discharge side; fig. 4,919 loading side. As shown the mixer is mounted on trucks with steam power and batch charging hopper; also with baffle plate attached to inside of discharging chute effectually closing the drum opening while batch is being mixed, thus absolutely preventing slopping. This discharge chute may be operated from either side of the machine.



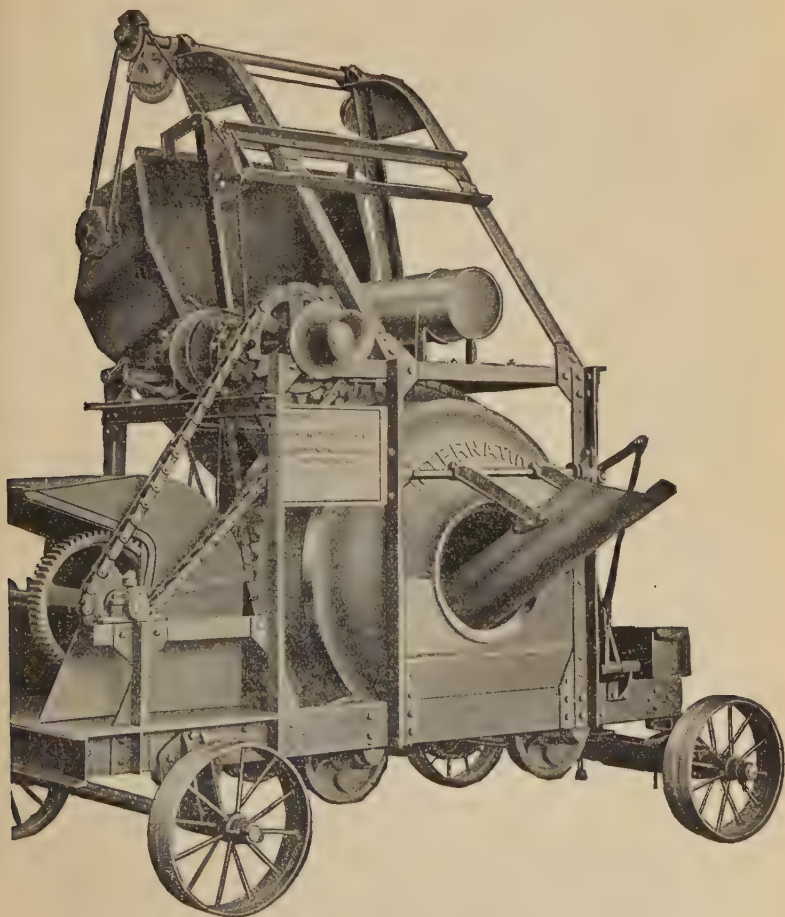
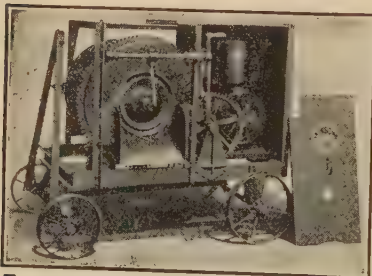
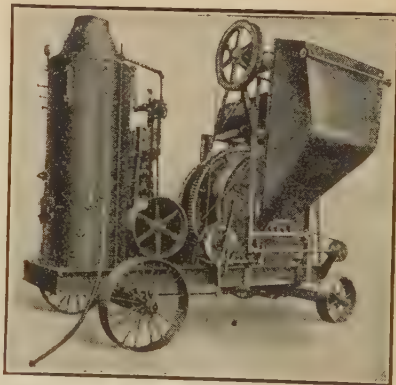
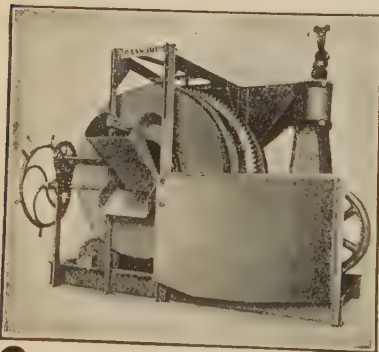
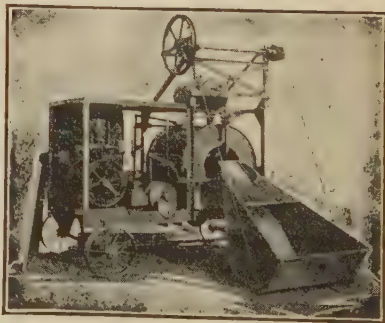


FIG. 4,920.—International concrete mixer on truck.

**A****B****C****D****E**

FIGS. 4,921 A to 4,921 E.—**A**, Ransome improved bantam mixer, on trucks with gasoline engine; **B**, Ransome standard building mixer, on trucks with steam engine and boiler, power loader and automatic water tank; **C**, Ransome standard building mixer on skids with steam engine and batch hopper; **D**, Ransome improved bantam mixer on trucks with gasoline engine power loader and water tank; **E**, Ransome standard building mixer on trucks with 4-cylinder gasoline engine, power loader and automatic water tank.

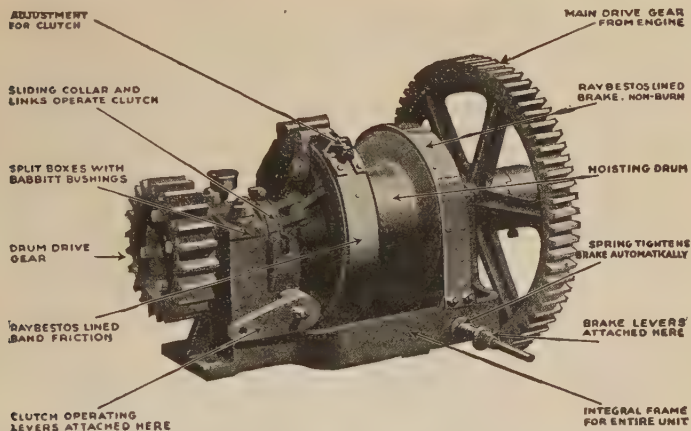


FIG. 4,922.—Smith concrete mixer. Skip hoisting mechanism. *It consists of a contractable band rotating with the shaft around a machined drum surface, which is case integral with the hoist drum. When the hoisting lever is operated, the band is contracted onto the drum surface until it causes the drum to rotate with it. When the pressure on the clutch is released, the band lets go of the drum surface, which then ceases to revolve.*

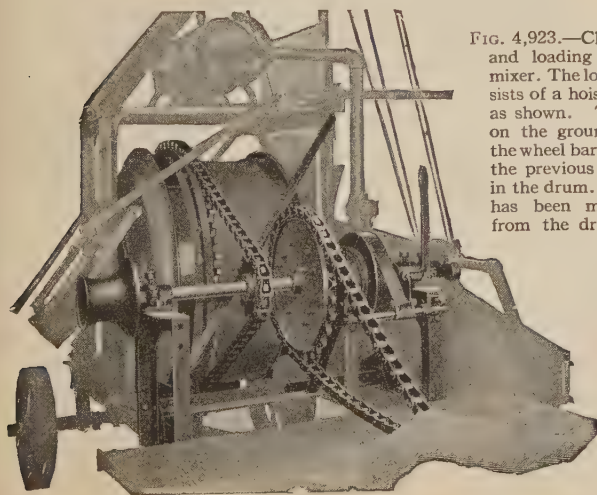


FIG. 4,923.—Chain drive for turning and loading drum of chain belt mixer. The loading mechanism consists of a hoisting drum and clutch as shown. The loader is charged on the ground level directly from the wheel barrows, being filled while the previous batch is being mixed in the drum. As soon as this batch has been mixed and discharged from the drum, the loader is elevated and another full batch emptied into the drum. The loader bucket is raised and lowered by means of a four part line. The cable used is three-eighths inch plow steel, six strands of 19 wires each attached to a hoisting drum operated by a wood friction clutch.

Figs. 4,918 and 4,919 show both sides of the Lakewood mixer and give a very good idea of the power equipment. As shown the mixer is at one end of the frame and the boiler at the other, the engine being between the two. The figure also shows clearly the transmission between the engine and boiler consisting in this case of double reduction spur gearing.

CHAPTER 88

Placing Concrete

After concrete has been mixed it must be placed while in its plastic form. In fact concrete should be placed as soon as it is thoroughly mixed, or at the longest within 30 minutes. The placing of concrete including its transportation from the mixer to point of delivery is an art in itself. The methods of placing vary with working conditions and the nature of the construction.

In handling concrete, not only are the raw materials often conveyed to considerably distant points, but in addition this must be done in an economical manner. The particular method adopted in any case will depend upon the size of construction and various other conditions.

The several general methods employed are by means of:

1. Pails
2. Wheel barrows
3. Carts
4. Boom
5. Cableways
6. Chutes

Pails.—On very small jobs, such as minor repairs or the building of small piers, etc., the concrete may be conveyed

from the mixing platform to the point of placement in an ordinary pail.

Wheel Barrows.—In some cases, on small and moderate size jobs, the cost of an elaborate placing plant can be avoided by the use of wheel barrows. For this purpose the ordinary wheel barrow is objectionable in that too great a proportion of the weight of the concrete must be supported by the man rather than by the wheels. This results in fatigue with resultant slowing down of the work.

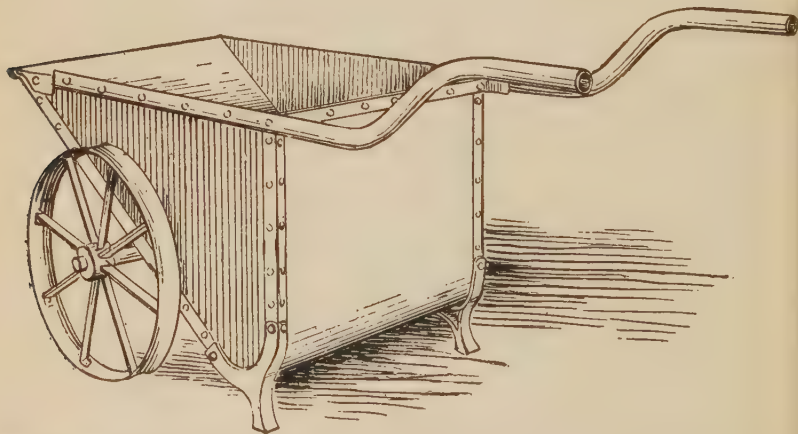


FIG. 4,924.—Semi-balanced concrete wheelbarrow relieving the hands of a considerable portion of the weight of the concrete.

A semi-balanced wheelbarrow adapted to conveying a considerable quantity of concrete at one time is shown in fig. 4,924.

In the ordinary flat pan wheelbarrow a man can handle about $1\frac{1}{2}$ to 2 cu. ft. of concrete, 25 ft. in 3 minutes.

In the flat pan type an objectionable feature is that the speed must be cut down due to care required to keep the concrete slopping over the sides.

Carts.—Two wheel carts are better adapted to conveying concrete than wheel barrows, especially on jobs of size, because of the larger capacity and balanced load the latter relieving the man of practically all of the lifting effort. The usual two wheel cart is of 6 cu. ft. capacity in which about $4\frac{1}{2}$ cu. ft. of concrete can be carried by one man. In choosing between carts and wheel barrows it should be noted that for carts a wider and more expensive scaffolding is required.

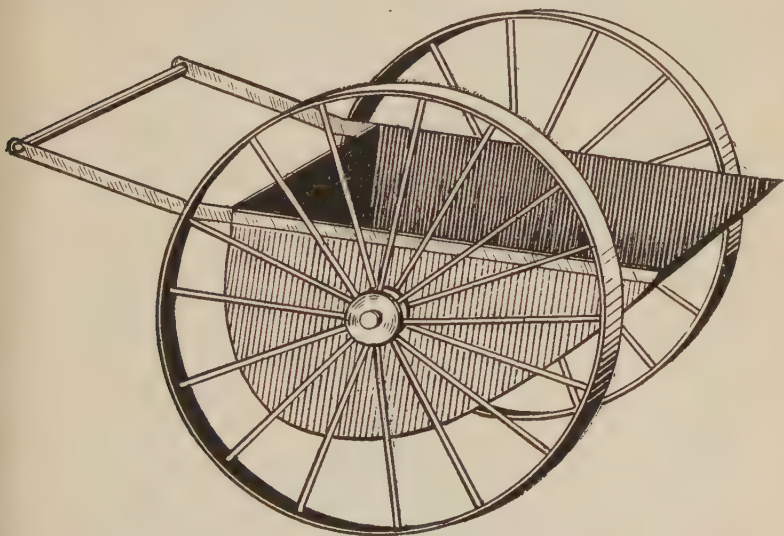


FIG. 4,925.—Balanced concrete cart. Capacity greater than wheelbarrow and the load being balanced is moved with less fatigue than with unbalanced wheelbarrow however more expensive scaffolding is required than for wheelbarrows.

Booms.—For a small radius of placement as in steel pavement construction concrete mixers are sometimes provided with swinging booms that may be swung to various radial positions. Working on this boom is a traveling and dumping

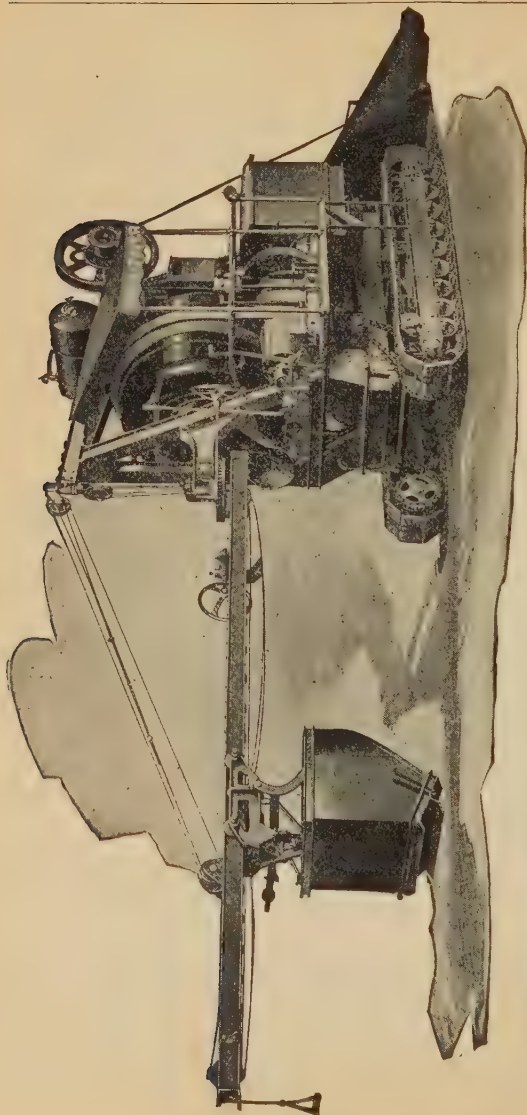


FIG. 4,926.—Smith radial boom street paver.

bucket, the arrangement permitting placing the concrete at any point within the arc of action. The booms on these machines are 20 ft. or more in length. The operation of a typical machine of this type is as follows:

Standing on the platform at the right, the operator raises the pivot hopper, empties the water tank, operates the discharge chute, sends the bucket out along the boom, and controls the point of automatic dumping almost without effort. From the same position he controls the engine, operates the traction clutch and steers the machine. A two barrow pivot hopper, across which extends a dumping bar to prevent the wheel barrows running back,

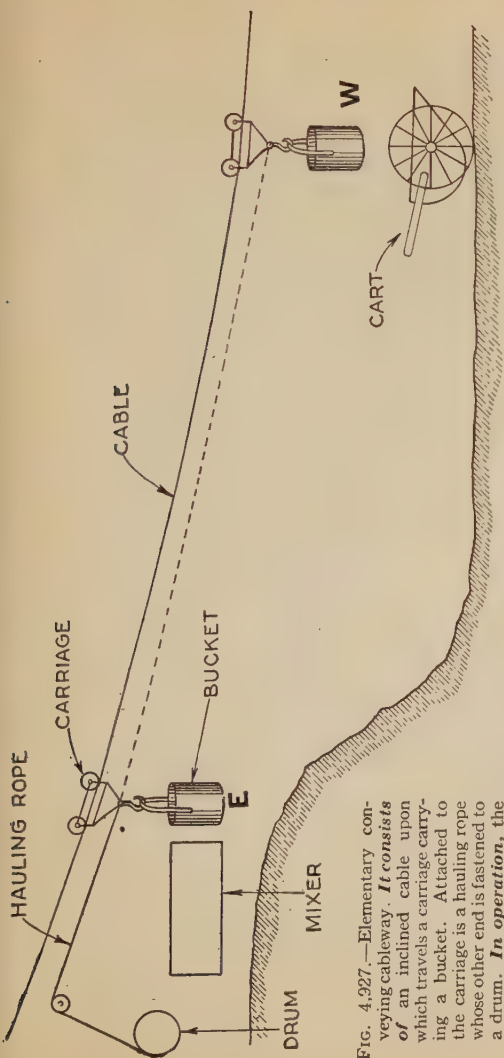


FIG. 4,927.—Elementary conveying cableway. *It consists of an inclined cable upon which travels a carriage carrying a bucket. Attached to the carriage is a hauling rope whose other end is fastened to a drum. In operation, the bucket at E, alongside the mixer is filled with concrete, the brake on drum released allowing the bucket to travel (by gravity) to position W, where it is dumped into a cart. When empty it is hauled back for another load by winding the hauling rope on the drum. The latter may be arranged to operate either by hand or engine drive.*

permits quick charging. For discharging, either a boom and automatic dumping bucket or a distributing chute is provided. A machine of this type is shown in fig. 4,926.

Cableways.—The term cableway denotes an apparatus having a bucket which is supported by and travels on a cable. There are numerous types of cable ways, which, with respect to function may be classed as:

- 1, Conveying
2. Hoisting and conveying

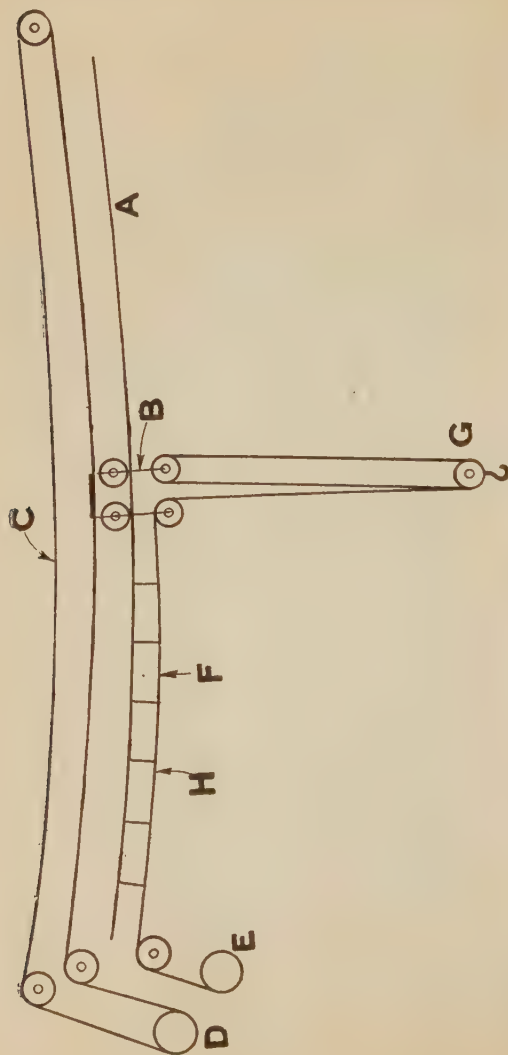


FIG. 4.928.—Elementary hoisting and conveying cableway. It consists of a track cable **A**, and carriage **B**, moved by the endless traction rope **C**, and by the power drum **D**. The hoisting of the load is accompanied by the power drum **E**, through fall rope **F**, raising the fall block **G**, suspended from the carriage. The fall-rope carriers **H**, support the fall rope, otherwise the weight of this sagging rope would prevent the fall block **G**, from lowering when without load. Where it is possible to obtain a minimum inclination of 20 deg. on the track cable, the traction-rope drum **D**, is provided with a brake and is not power-driven. The carriage then descends by gravity, pulling the fall and traction ropes to the desired point. Brakes are applied to drum **D**, stopping the carrier. The fall block is lowered, loaded and raised. If the load is to be carried up the incline, the carriage is hauled up by the fall rope. With this type, the friction of the carriage must be greater than that of the fall block, or the load will run down. The most recent development is the use of self-filling grab buckets, operated from the carriages of cableways, which are lowered, are hoisted, carried to dumping position and discharged.

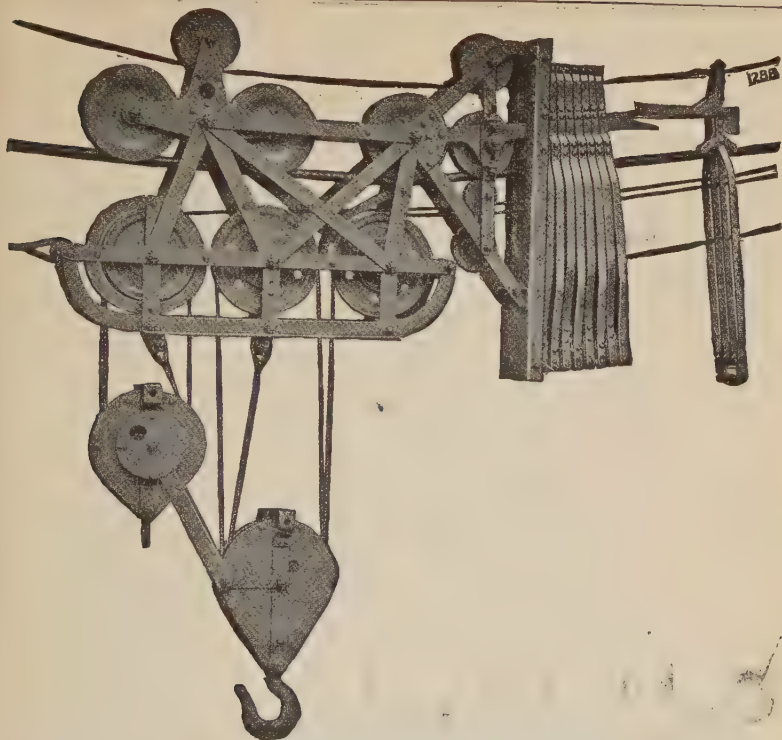


FIG. 4,929.—Lidgerwood high speed cableway carriage and shock-absorbing fall rope carriers "Panama Type." The carriage has three main cable wheels besides the wheel supporting the carrier horn. The two rear wheels are placed in an equalizer frame. In this way the weight is equally distributed upon the wheels. This makes for efficiency in operation and prolongs the life of the main cable and of the cable wheels. To insure the carrier horn always entering the opening of the carriers in the same position in picking up the carriers, it was necessary to keep the horn at all times in the same correlation with the main cable. The horn is, therefore, self-adjusting. It is pivoted to the carriage and the horn frame rides on a wheel on the main cable. Speed 18 ft. per minute.

NOTE.—*Steam Hoists* are also largely employed for cable excavators. In the case of steam hoists, there is no necessity for a two speed drum, as the characteristics of the steam engine with its ability to pull hard at slow speed and speed up at reduced loads as in raising the bucket and conveying same, give the necessary speed variations. For instance, on the larger size cable excavator, as 12" X 12" double cylinder hoist with the usual single reduction gearing accomplishes the same speed variations as the two speed electric hoist. Manufacturers carry a full line of steam hoists, with, or without boilers, for cable excavators, the design and construction throughout being very rugged and embodying the good features of the two speed electric hoist, with the exception of the two speed device.

FIG. 4,931.—Lidgerwood slow speed carriers. By slow speed is meant any speed below 1,000 feet per minute. This carrier retains most of the features of the high speed carrier without its shock-absorbing features. It is recommended for cableways which are not required for long service and where economy in first cost is an important consideration.

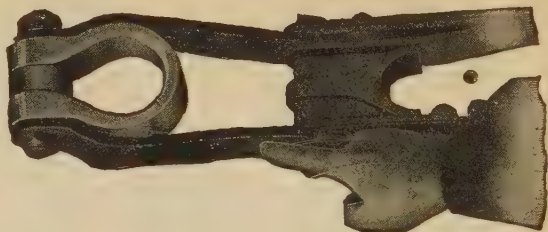
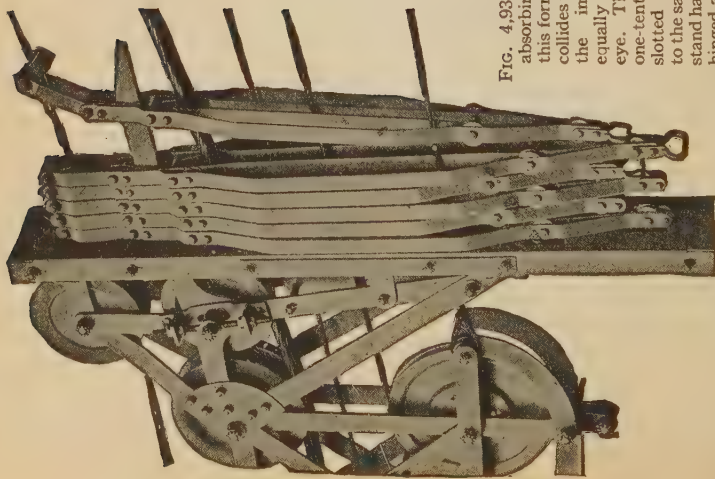


FIG. 4,930.—Lidgerwood shock absorbing fall rope carriers. In this form of carrier, the button collides with an eye or ring, and the impact is distributed equally around the face of the eye. The eye does not weigh one-tenth as much as the slotted head and if subjected to the same strains would withstand harder service. The eye is hinged and the head of the carrier is also hinged below. The shock-absorbing action of this construction is so great that carriers of this style have been experimentally operated for hours at a time without damage at speeds up to 3,000 feet per minute.



rier is also hinged below. The shock-absorbing action of this construction is so great that carriers of this style have been experimentally operated for hours at a time without damage at speeds up to 3,000 feet per minute.

In cases where the mixer is at some elevated point and the concrete is to be delivered at some distant point the conveying type of cableway answers the purpose as shown in fig. 4,927.

A hoisting and conveying cableway hoists the load at any point under the cable and conveys it to any other point. Its construction and operation is shown in fig. 4,928.

Cableway buckets are of several types as shown in the accompanying illustrations. They are usually of 2 cu. yd. capacity. A gate controlled by levers regulates the flow of concrete.

Cableways usually require a considerable outlay but on large operations where the conditions are suitable they will prove economical.

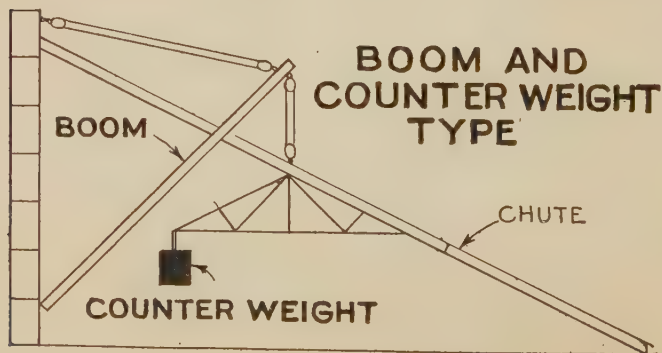
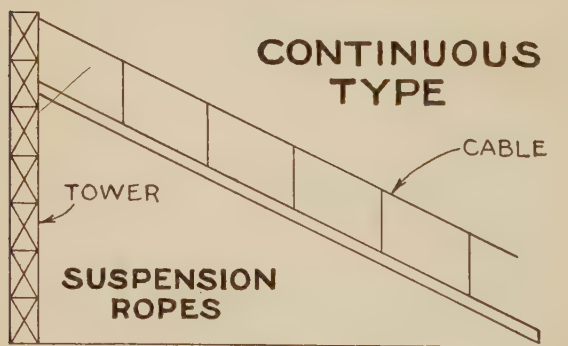
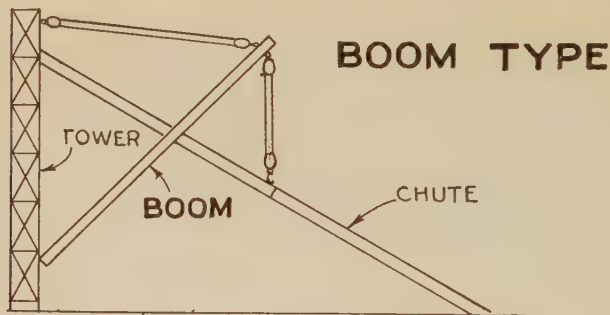
Chutes.—The placement of concrete by chutes has been in use so long that practically every construction man is familiar with the method.

It is perhaps more extensively used than any of the other methods described except possibly the cart system. Placement of concrete by chutes consists briefly in hoisting the concrete in a tower located at the mixer by means of a skip bucket and engine, and delivering it at some elevated point on the tower to an inclined chute or trough through which it flows by gravity to the desired point of delivery. The chutes may be extended in sections to cover any area within a radius of from 10 to 300 ft. or more.

There are three general types of plant:

1. Boom plant
2. Continuous line plant
3. Boom and counterweight plant

The boom plant may be either stationary or portable; the continuous line plant is usually stationary. Elementary chutes illustrating the three general types are shown in figs. 4,932 to 4,934. The old tripod method of supporting chutes has been gradually abandoned for the more flexible boom



FIGS. 4,932 TO 4,934.—Elementary chutes illustrating the three general types.

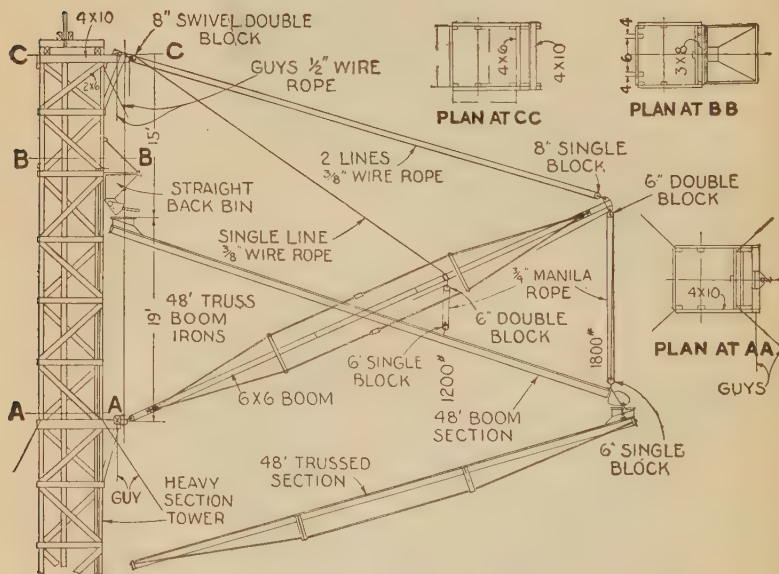
FIG. 4,935.—Ransome swivel joint being made up of a splash hood attached to the discharge end of one trough unit and a hopper head attached to the receiving end of the other trough unit.



FIGS. 4,936 and 4,937.—Ransome flexible drop chute $12\frac{1}{2}$ ft., with drop chute hopper and view of hopper. One chute with a hopper head or a line hopper with flexible drop chutes attached may be used under line gates. For exceedingly long drops the 8 ft. lengths of 8 in. drop chutes are preferable to the shorter lengths of 8 in. flexible drop chutes.

plant, although tripods are still used as an auxiliary to the boom and continuous line plants.

On many jobs various modifications and combinations of the three general types are employed. A study of the accompanying illustrations will give a clear idea of what can be done with the various types separately and in combination.



FIGS. 4,938 to 4,941.—General construction of boom chute plant.

Slope or Inclination of Chute.—There has been much theoretical discussion on this, but actual practice has shown that it is safest to stick to a slope of one vertical to three horizontal. The only variations from this almost standard slope are in the use of fine gravel concrete, where a slope of one to four is practical, and for concrete in which the coarse aggregates are stone

or slag $2\frac{1}{4}$ ins. or larger where it is advisable to use a slope of one vertical to two and one-quarter horizontal.

There are two facts that have become established in the chuting of concrete:

1. Only well mixed concrete can be handled.



FIG. 4,942.—Ransome 32 ft. counter-weight chute. It will carry a 32 ft. swivel head section at its lower end.

2. Concrete with an excess of water cannot be handled successfully.

In all chute installations care must be taken to have the chutes at a workable inclination, and to have the inclination the same all along the line, to obtain uniform rate of flow.

When the material has to be conveyed to a considerable distance the pitch of the chute must be greater than for a short distance.

The following inclinations are recommended:

Inclination of Chute

Distance	50 ft.	100 ft.	400 ft.
Pitch.....	1 to 6	1 to 4	1 to 3

Shape of Chute.—For years both theory and practice

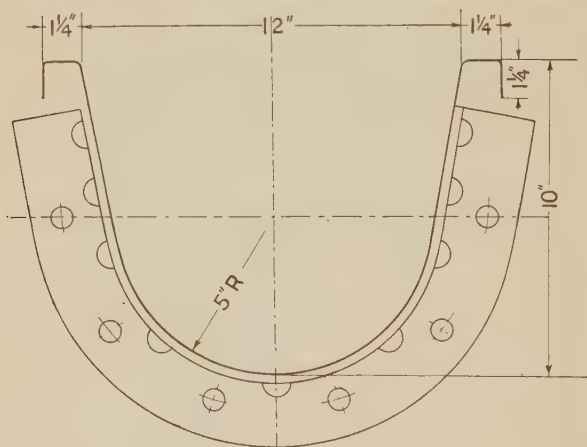


FIG. 4,943.—Sectional shape of Ransome chute.

demonstrated beyond question that the flow of materials in conduits of all kinds depends upon the amount of friction between the material and the surface of the conduit, and that the shape, giving the minimum of wetted surface for any given volume of material carried, insures the greatest carrying capacity.

The shape adopted by the Ransome Co. is shown in fig. 4,943.

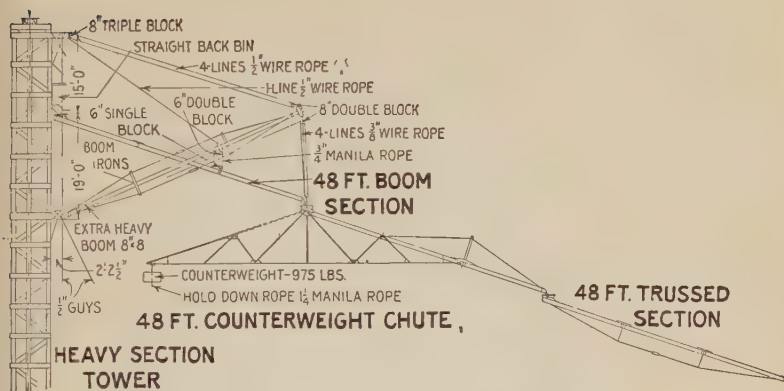


FIG. 4,944.—Combination open wooden boom and counter-weight chute plant.

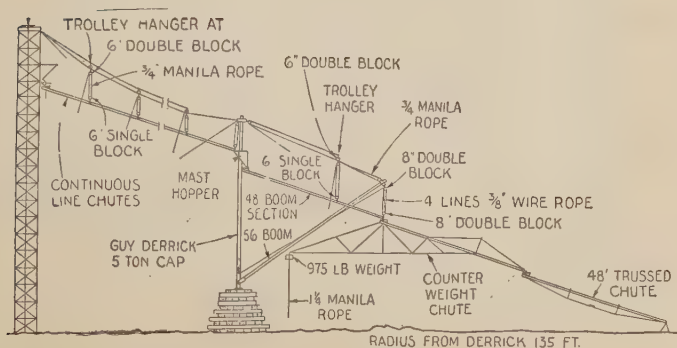


FIG. 4,945.—Combination continuous line boom and counter-weight chute plant.

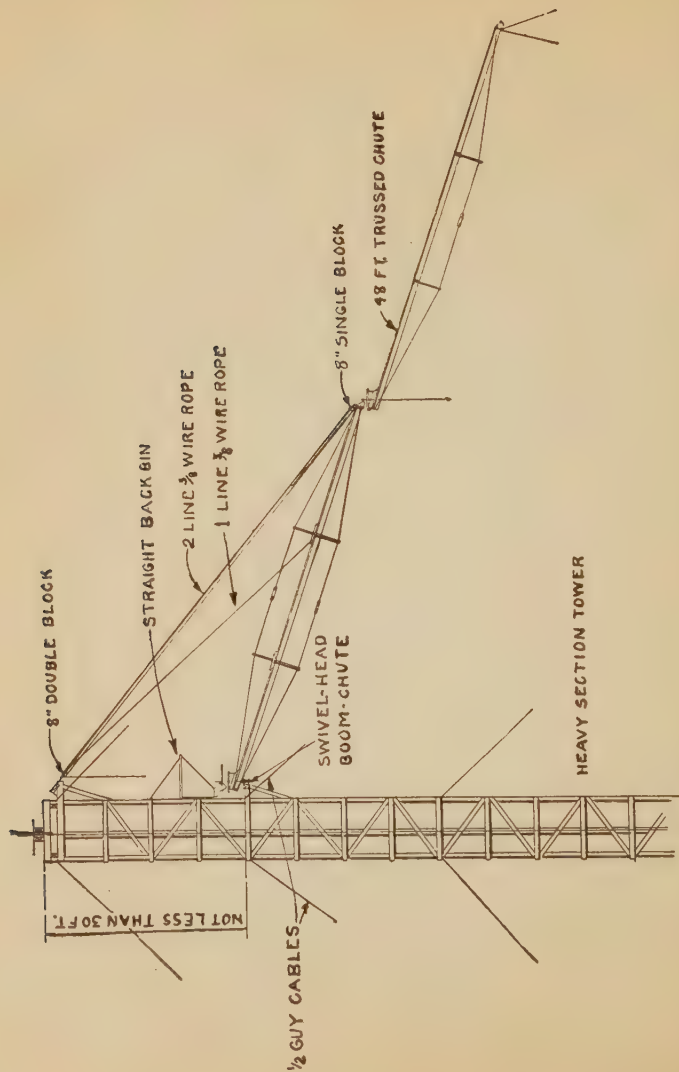


FIG. 4,946.—Ransome boom chute plant.

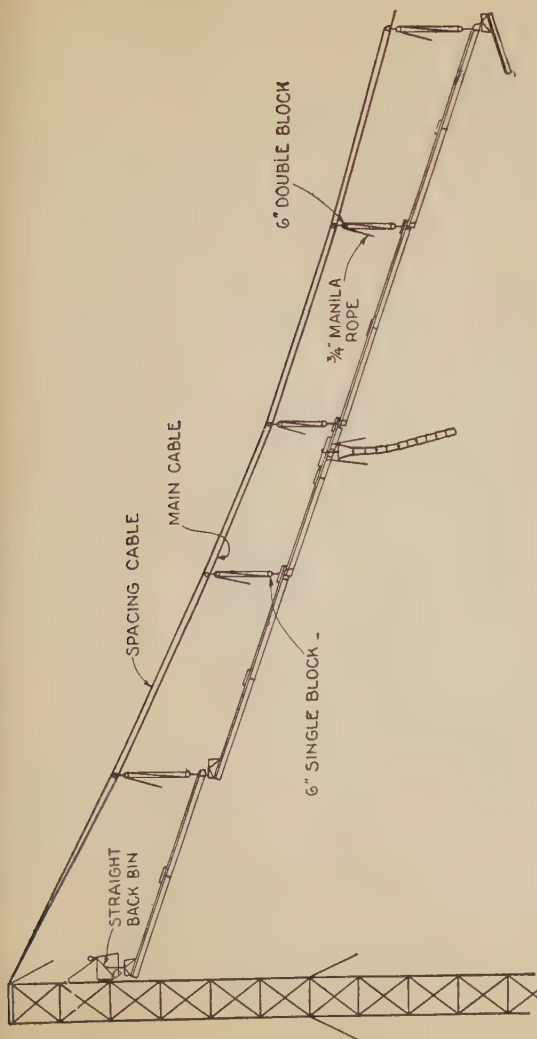
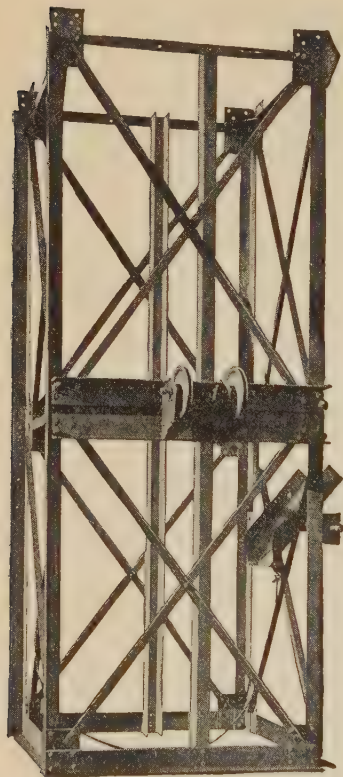


FIG. 4,947. —Continuous line chute plant showing use of gate and flexible drop chute.

Size of Chute.—The size of the chutes has been another point on which there has been much speculation. In the early stages of this method of handling concrete there was the greatest diversity of opinion.

Some experienced engineers claim a 6 in. chute is ample, while there have been instances where a chute more than 6 in. has been thought to be necessary. Actual



practice has shown that the smaller chutes have ample capacity to carry the concrete turned out by even the larger mixers when there are no large aggregates; but the trouble with the smaller chutes has been that very often large aggregates work into the concrete and cause trouble.

Another fact that was not taken into consideration at the first was that it is not practical to operate a chute flowing full of concrete. For years, in the designing of hoist buckets some leeway was usually allowed between the capacity of the bucket in the amount of actual concrete it would handle and in its water measure. This allowance has averaged about 3 ins. The best results will be obtained if the chutes be operated about two-thirds full.

FIG. 4,948.—Bottom section of Ranome steel tower. Light steel towers are for use alongside buildings where the concrete can be taken away by carts or a short length of chuting. Sliding frames are not used on these towers. Heavy steel towers have the front posts made of Z bars, allowing a sliding frame to be operated. The heavy steel towers are strong enough to carry a boom plant with a 48 ft. counterweight chute having its inner end tied down and carrying at its unsupported outer end a 48 ft. swivel head chute. Standard towers are made up in sections 15 ft. long, sub-divided into two panels. Each section is made up of two sides each riveted as a rigid unit and connected across the front and back with horizontal and diagonal bracing. Furthermore, at each panel point there are four corner braces in a horizontal plane to prevent any twisting of the tower. The tower should be guyed every 45 ft., connections being provided in each section for that purpose. Each tower is made up of a bottom section, carrying auxiliary chute and swivel sheave, a top frame with sheaves for hoist line and sliding frame line, and as many intermediate sections as required.



FIG. 4,949.—Ransome sliding frame on tower, for use on both steel and wood towers. For steel towers, the sliding frames have a groove on each side, which engages the outer end of the Z bars, which form the front posts of the tower. For wooden towers the sliding frames have a groove on each side sufficiently large to engage a 2×6 strip bolted to the outside of the tower. The frames, when in working position, are secured by safety bolts. A boom bracket 7 ft., 6 ins. long distributes the thrust of the boom over one panel of the tower. A complete sliding frame for an open boom plant consists of a rope bracket, a bin frame and a boom bracket and covers a length of 42 ft. For a boom chute plant, a bin frame and a boom chute bracket only are required. The outer end of the boom chute is guyed from the top of the tower.

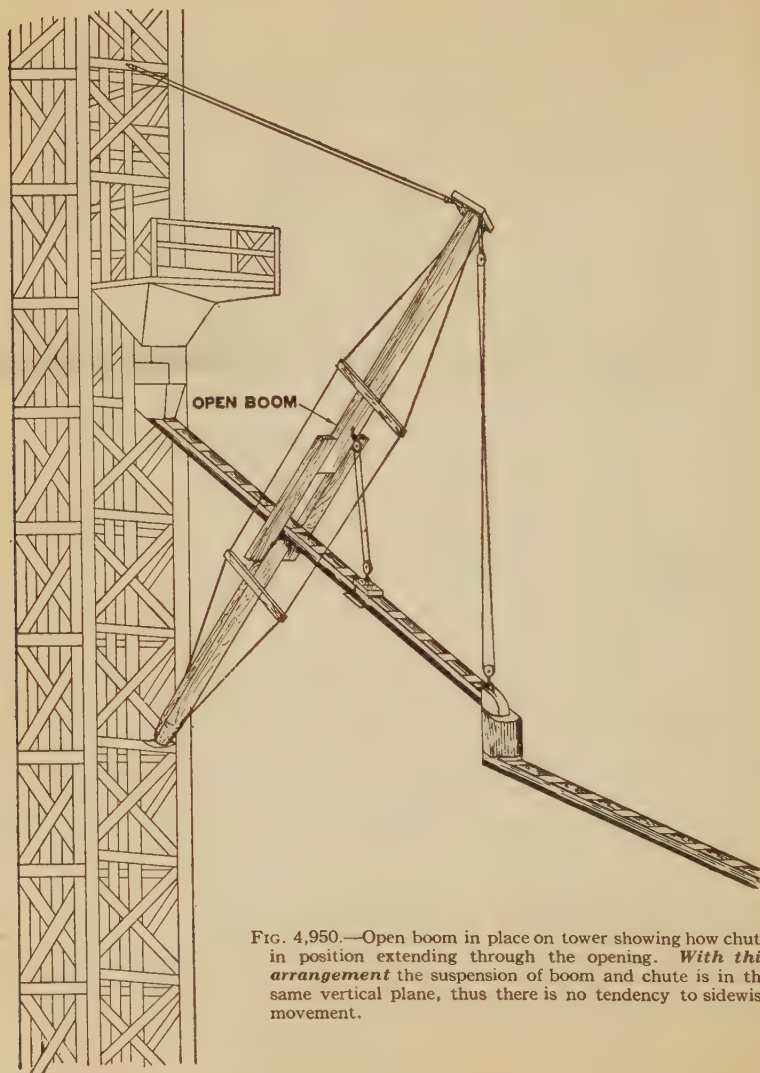
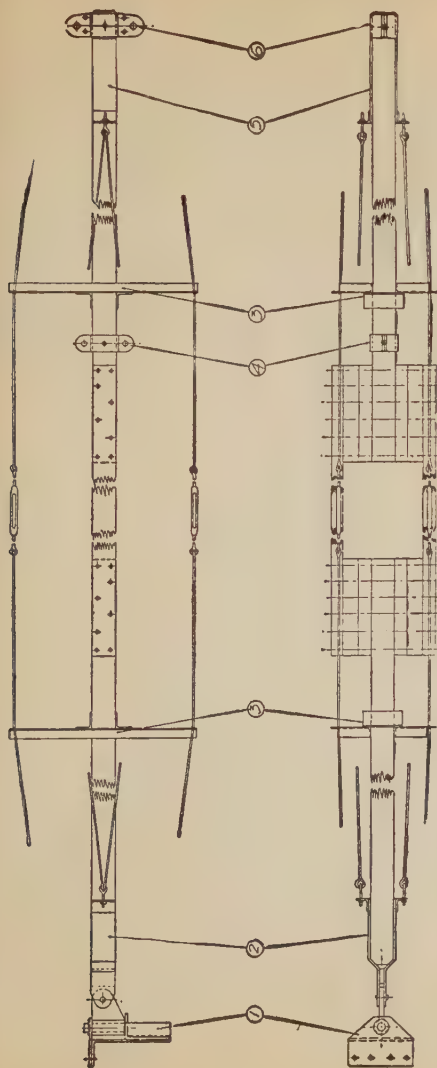


FIG. 4,950.—Open boom in place on tower showing how chute in position extending through the opening. *With this arrangement* the suspension of boom and chute is in the same vertical plane, thus there is no tendency to sidewise movement.



FIGS. 4,951.—Assembly of Ransome open wooden beam showing construction.

The size shown in fig. 4,943 is ample to handle as large an aggregate as should be used in a one-yard mixer and the depth of 10 ins. gives ample clearance under the cross bracing, so that there is no tendency for an occasional large stone to hit the cross bracing and cause the concrete to pile up and overflow at this point.

The carrying capacity of a chute depends upon the rate of flow. One authority gives the rate of flow at 75 to 100 ft. per minute, while another gives it at 250 ft. per minute.

The average of the two rates may be taken as safe. It should be noted that the size of the hopper head has an important bearing on the

NOTE.—*Spouts or chutes.* The handling of concrete through spouts or chutes at the present time is in more extensive use than any of the foregoing methods of distribution, with the possible exception of distribution in carts. The economic features of spouting are attractive. To raise concrete vertically in a tower by means of a skip bucket and engine located at the central mixer plant, then distributing by gravity through channels which can be arranged in convenient sections to cover any area with a radius from 10 to 300 ft. from the base of the tower appeals strongly both to engineering and to business sense. Further, the ease of handling by gravity is usually greater and the time cost per cubic yard for placing is usually less than in transferring the same quantity of material in hand-barrows, in cableway buckets or in carts.—Hool & Johnson.

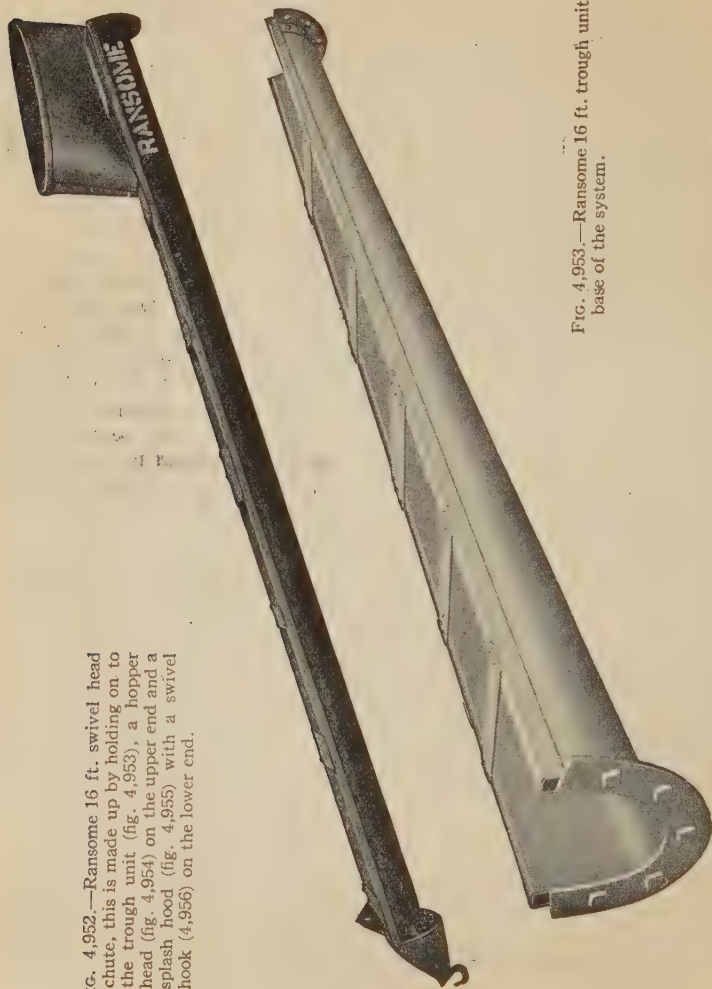


FIG. 4,952.—Ransome 16 ft. swivel head chute, this is made up by holding on to the trough unit (fig. 4,953), a hopper head (fig. 4,954) on the upper end and a splash hood (fig. 4,955) with a swivel hook (4,956) on the lower end.

FIG. 4,953.—Ransome 16 ft. trough unit or base of the system.



FIGS. 4,954 to 4,956.—Ransome chute fittings. Fig. 4,954, hopper head; fig. 4,955, splash hood; fig. 4,956, swivel hook.

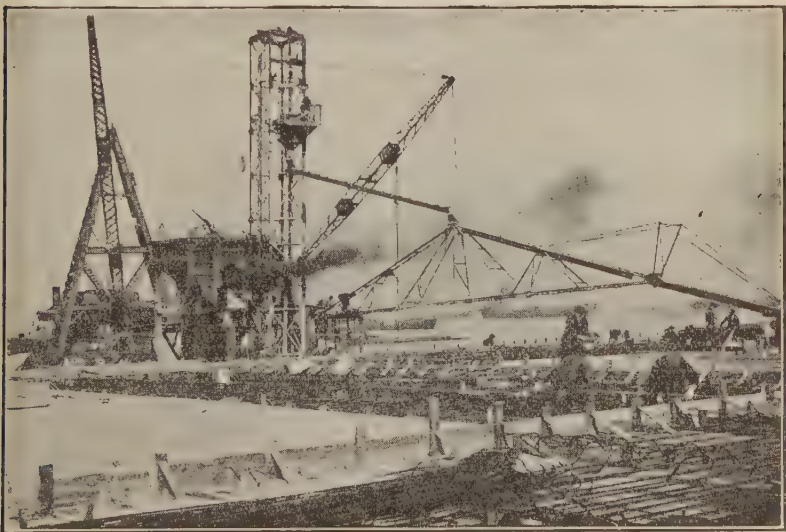


FIG. 4,957.—Floating Ransome steel tower counterweight chuting plant. Municipal piers, Stapleton, S. I.



FIG. 4,958.—Ransome flexible joint for continuous line chute.



FIG. 4,959.—Ransome line gate shown in closed position. The gate is opened by pulling a rope attached to the lever.

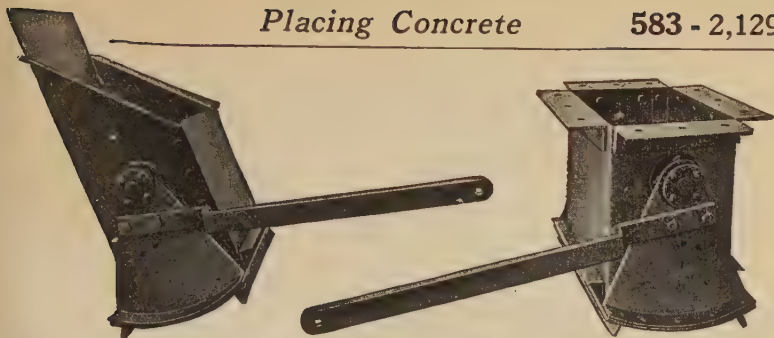


FIG. 4,960 and 4,961.—Ransome bin gates. Fig. 4,960 vertical; fig. 4,961 bottom. They are built with radial cut off. Vertical bin gates are used on the bottom of bins for either sand, crushed stone or gravel. Bottom bin gates are used on bottom of bins when either sand, crushed stone, gravel or concrete is to be discharged to the side. Front bin gates are used for the same purpose as the bottom gates, but are attached to the vertical side of the bin.



FIG. 4,962.—Ransome wooden tower, 450 ft. continuous line chuting plant, Union Ship-building Co., Baltimore, Maryland.

capacity of a chute plant. There is a change in direction of the flow of concrete at the hopper head which momentarily checks the rate of flow, and consequently a piling up of the concrete takes place until the original velocity can again be acquired.

Construction of Chutes.—In general, chutes are of two kinds known as:

1. Swivel head
2. Continuous line

and the same units are used in the construction of both. The basis of the system is the trough unit shown in fig. 4,953. The swivel head chute is made up as shown in fig. 4,952, by attaching the parts shown in figs. 4,954 to 4,956.

A 32 foot continuous line chute is made the same as a 32 ft. swivel head chute, except that the hopper head, splash hood and swivel hook are omitted, and a *flexible joint* attached at the lower end as shown in fig. 4,958. Concrete may be drawn from various points in a continuous line chute by installing line gales, as shown in fig. 4,959. Various other chute fittings are shown in the accompanying cut.

CHAPTER 89

Concrete Forms

Since a concrete mixture is semi-fluid, it will take the shape of anything into which it is poured. Accordingly moulds or *forms* are necessary to hold the concrete to the required shape until it hardens, the concrete being “poured” into the moulds.

For a number of classes of concrete construction and products such, for instance, as sewers, silos, double monolithic building walls, concrete block, brick and tile, there are various types of patented forms and machines which permit quite a range of adjustments to adapt them to various dimensions of structures or products for which they are designed. Such forms or moulds are almost invariably made of metal, sheet steel being the material principally used.

The length of time necessary to leave the forms in place depends on the nature of the structure.

For small construction work where the concrete bears external weight, the forms may be removed as soon as the concrete will bear its own weight, that is, between 12 and 48 hours after the concrete has been poured.

Where the concrete must resist the pressure of the earth, or water (as in retaining walls or dams) the forms should be left in place until the concrete has developed nearly its final strength; this may be as long as three or four weeks, if the weather be cold, or anything else prevent quick curing.

Forms must be water tight, rigid and strong enough to sustain the weight of the concrete. They must also be simple and economical and if to be used

again, designed so that they may be easily removed and re-erected without damage to themselves or to the concrete.

The different shapes into which concrete is formed means that each job will present some new problems to be solved, but there are typical forms that will cover a large part of concrete construction.

Lumber for Forms.—By far the most of concrete building construction is done by using wooden forms. Various woods are used for forms, the selection depending upon the character of the work and the available supply in the local yards.

In general, forms are best made of any of the soft woods as they do not warp so easily when wet.

Contrary to the usual practice in building construction, green lumber or lumber which is only partly air dried will keep its shape in concrete forms for rectangular construction better than lumber that is kiln dried. If kiln dried lumber be used it should be thoroughly wet before concrete is placed. This is because the lumber will absorb water from the concrete, and if the forms be made tight, as they should be, the swelling from absorption will cause the forms to buckle or warp. Oiling or greasing the inside of forms before use is recommended, especially where forms are to be used repeatedly as it prevents absorption of water and also assists in keeping them in shape when not in use, and for removal.

Spruce seems to be the best all around material. It can readily be obtained in almost any locality and is undoubtedly an excellent lumber to use for joists, studs and posts. For sheathing, however, white pine is better than spruce by means of its smoothness and its resistance to warping, but this wood is generally too expensive (except for cornice and ornamental work) and spruce makes a good substitute. If white pine be used for sheathing, it should be noted that this kind of lumber is not durable because it is very soft and is accordingly not desirable where the forms are to be used many times.

Norway pine and southern pine are generally the most available and give satisfaction.

Hemlock is not usually desirable, especially for that part of form work which comes into contact with the concrete, but it is sometimes used for ledges, studs and posts. This wood is too coarse grained to be suitable for sheathing and is liable to curl when exposed to the weather or to wet concrete.

Form lumber should be free from loose knots or other defects and irregularities that would be reproduced by the concrete. It is often possible to build forms from stock lengths of lumber, without cutting, thereby saving material and labor. It is seldom economical to rework second hand lumber for forms. It costs about twice as much to construct forms of old lumber, hence, use new lumber.

Preparation of the Lumber.—All lumber should be dressed at least on one side and both edges, and in most cases it will be cheaper to have it dressed on both sides. Since forms are cleated, dressing is necessary in order that the face next the concrete will be uniform.

In footings and rough work that is not to show, practically any lumber can be used that will hold wet concrete, but for forms that are to be used again, the additional care of cleaning will pay the cost of having the lumber dressed.

In face work, where a smooth and true surface is important, the lumber employed should be dressed on all four sides. The edges may be cut square, mitred, or tongue and groove. The latter joint is nearer water tight and tends to prevent warping.

Beveled edge joint is desirable where dry lumber is used because buckling is prevented by the edges crushing as the boards swell. The tongue and groove joint, however, gives the best results under ordinary conditions. The tongue and groove joint is more expensive than the beveled edge joint, but it gives smoother surfaces after repeated use.

Joints in forms for columns, beams, and girders are sometimes made tight simply by dressing the lumber true to edge, forming a square or butt joint.

Classification of Forms.—Numerous types of forms are used

to meet the varied requirements met with in practice. These various types may be classified

1. With respect to the material, as:
 - a.* Wood
 - b.* Metal
 - c.* Composite
2. With respect to shape, as:
 - a.* Straight
 - b.* Circular
3. With respect to solid or hollow casts, as:
 - a.* Single
 - b.* Double
4. With respect to method of construction, as:
 - a.* Ordinary
 - b.* Unit
5. With respect to part of structure used for, as:
 - a.* Foundation
 - b.* Wall
 - c.* Steps
 - d.* Sidewalk
 - Etc.

Most forms are now made of wood, although steel forms are often used for work with large, flat surfaces, particularly sidewalks, curbs, roads and retaining walls and columns when the forms are to be used repeatedly. The erection and removal are the chief factors in economical designs of forms and each job should be thoroughly studied and forms designed with this point in view.

Construction of Forms.—Since concrete weighs from 130 to 150 lbs. per cu. ft. it must be evident that forms should be of substantial construction properly proportioned so as to be rigid against pressures due to the weight of material, thus avoiding

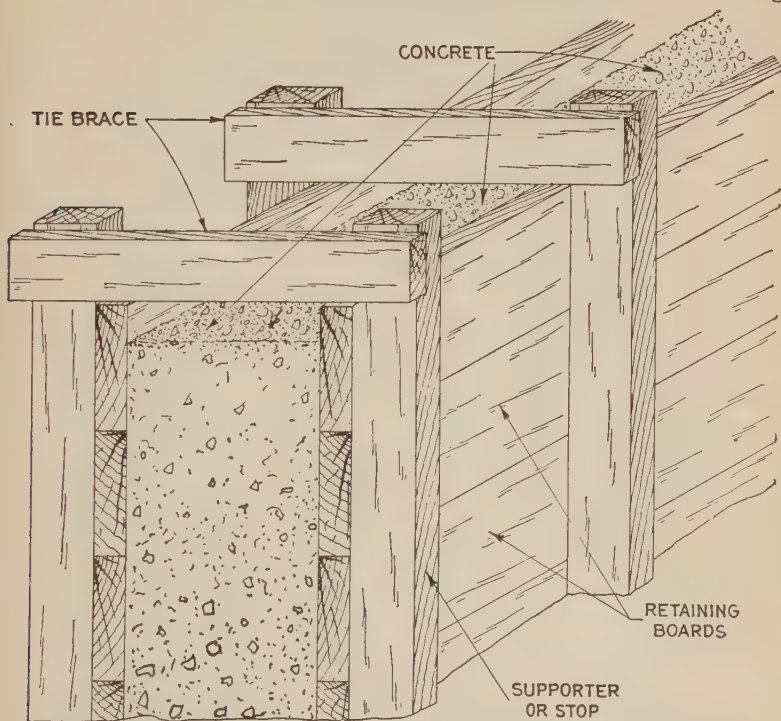


FIG. 4,963.—Elements of a concrete form showing the principal members: retaining board, supporters, braces.

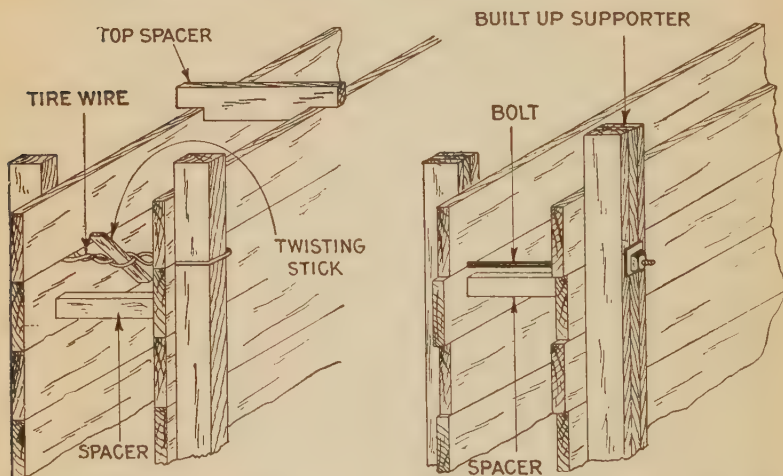
any bulging of vertical forms or sagging of horizontal forms. In the latter case any sagging will result in small cracks developing while the concrete is hardening, and these will gradually widen, preventing the construction having the desired strength.

To retain the concrete in position in its plastic condition till it hardens the forms are constructed of:

1. Retaining boards
2. Supporters, or studs
3. Braces

The ordinary arrangement of these members is shown in fig. 4,963. The thickness of the lumber varies according to its use.

For short spans between supports, such as floor slabs and wall forms,



FIGS. 4,964 and 4,965.—Twisted wire and bolt braces as used on concrete forms. With these types of braces spacers are used to insure maintaining the proper distance between the retaining boards. The tie wire braces are tightened by twisting.

1 in. stick is generally used; for columns either 1 in. or $1\frac{1}{4}$ in., according to the spacing of the yokes; for beam sides and bottoms 2 in.

For supporters, 2×4, 2×6, or in extreme cases 2×8 studs are used. The volume of the concrete and its depth determines the dimension and spacing of the supporters.

Forms constructed of 2×4 supporters with 1 in. retaining boards should have studs spaced not more than two feet apart, in order to prevent any

bulging of the sheathing when subjected to the ramming of placing concrete, and its outward pressure until hardened.

Instead of the cleat braces shown in fig. 4,963, sometimes twisted tie wires with spacers are used as shown in fig. 4,964, or bolts as in fig. 4,965.

If bolts be used they may be greased before concrete is placed so they can be driven out of the concrete easily when forms are removed. It is best to break the bond of the concrete around such bolts within 24 hours. This may be done by merely tapping them with a hammer. Wire ties are generally used and are cut when taking down forms, all of the wire, except the projecting ends, being left in the concrete.

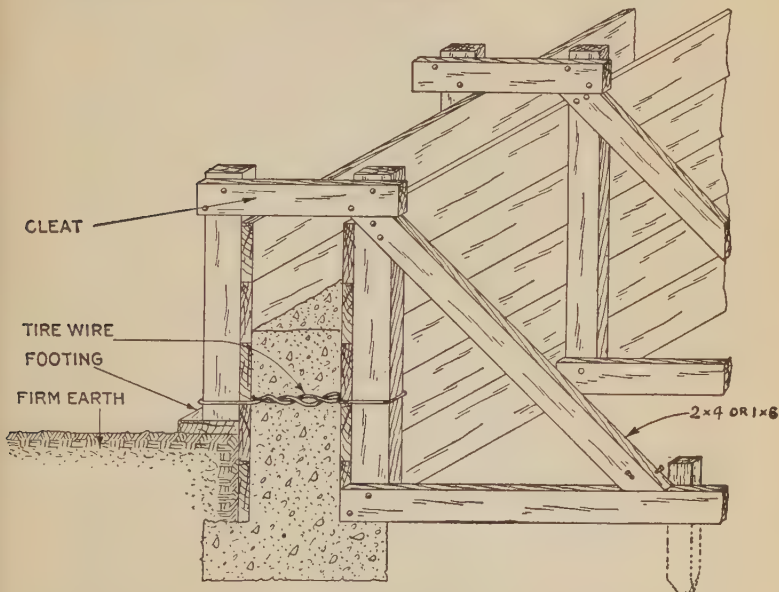


FIG. 4,966.—Single side foundation form, for foundation built in firm earth.

Foundation Forms.—For small foundations no forms are necessary if the soil be firm. In such case the trench is dug the exact size and filled into concrete, being careful not to knock earth from sides into the fresh concrete. With firm earth and

where an excavation is made for a cellar, a form for one side of the foundation wall such as shown in fig. 4,966 will suffice.

The form is held up on the brace foot to permit the concrete to run out a little under the form and make a footing or broader base for the wall. Where the earth is soft a two side form is required as shown in fig. 4,967.

For a framed structure sill bolts may be cast into the cement by placing the bolts in position on top the form as shown in fig. 4,974.

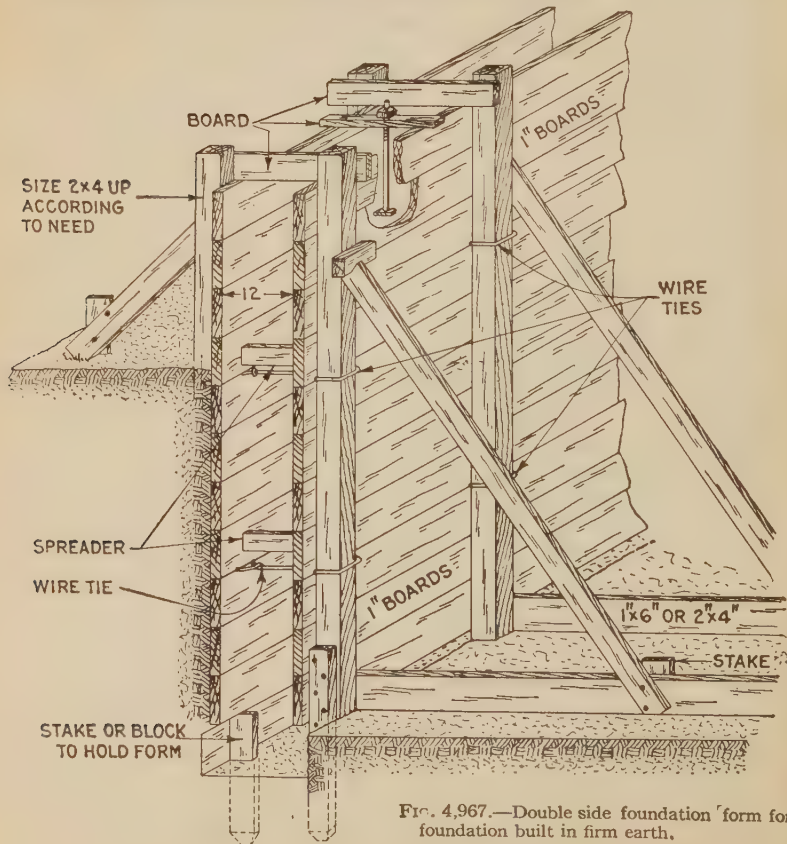
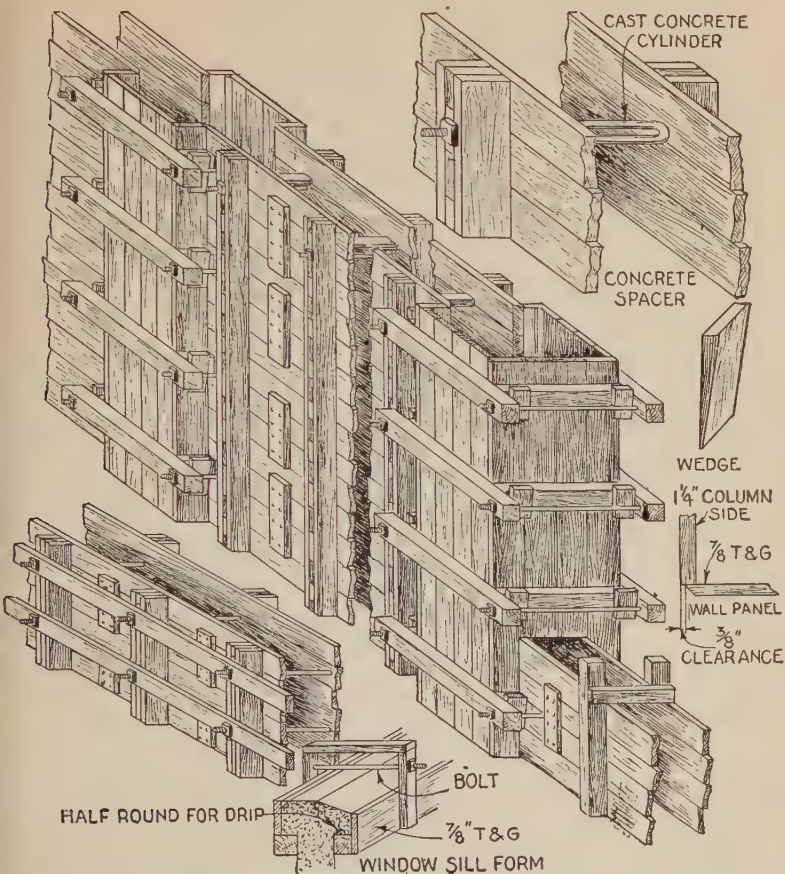


FIG. 4,967.—Double side foundation form for foundation built in firm earth,



FIGS. 4,968 to 4,973. — Single forms for wall construction. These are made up of convenient sized panels of $\frac{7}{8}$ tongue and groove boards cleated together. These are tacked on standards made up of two 1×4 pieces with 1 in. separator blocks. Through the standard and the forms are run $\frac{5}{8}$ in. bolts. The forms are kept the proper distance apart by small sticks cut to a length equal to the thickness of the wall. These sticks are knocked out as the concrete is poured. Another method of keeping the forms apart is by using pre-cast cylinders of concrete with a hole for the bolt through the center. These blocks remain in the concrete. The figures also show the method of connecting wall and column forms when they are poured at the same time and also the construction of curtain-wall forms. The small detail shows the forms for the window sills when they are poured after the walls.

Wall Forms.—For walls above ground two side forms are required, and these as before mentioned should be of substantial construction so as to prevent bulging by the lateral

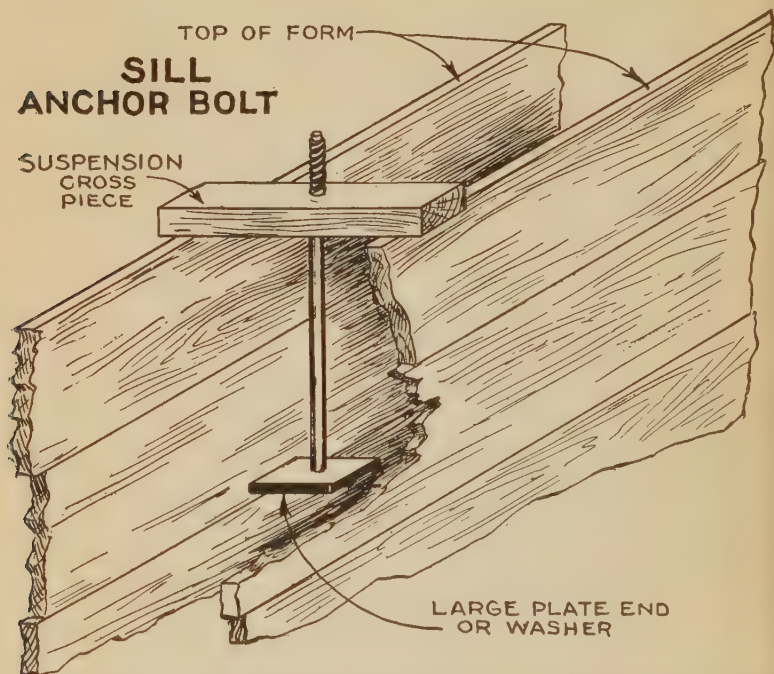
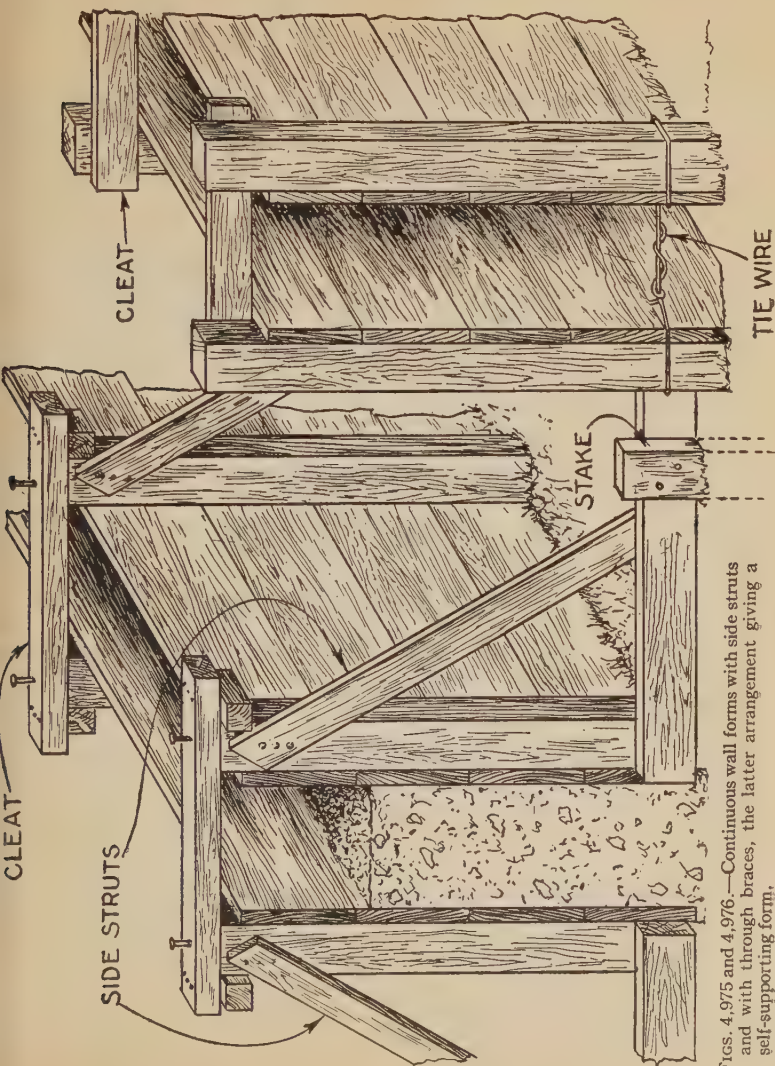


FIG. 4,974.—Method of suspending sill anchor bolts for casting in the concrete. Sills should be properly anchored in first class construction, instead of the usual objectionable practice of just laying them on the foundation.

pressure due to the weight of the concrete in its plastic condition. These may be of several types as:

1. Continuous
2. Full unit
3. Layer unit



FIGS. 4,975 and 4,976.—Continuous wall forms with side struts and with through braces, the latter arrangement giving a self-supporting form.

- a. Continuous
- b. Sectional

depending on the desired degree of economy in the use of lumber.

Figs. 4,975 and 4,976 show detail of continuous form with side struts and through braces. In fig. 4,975 the forms are braced strongly against the

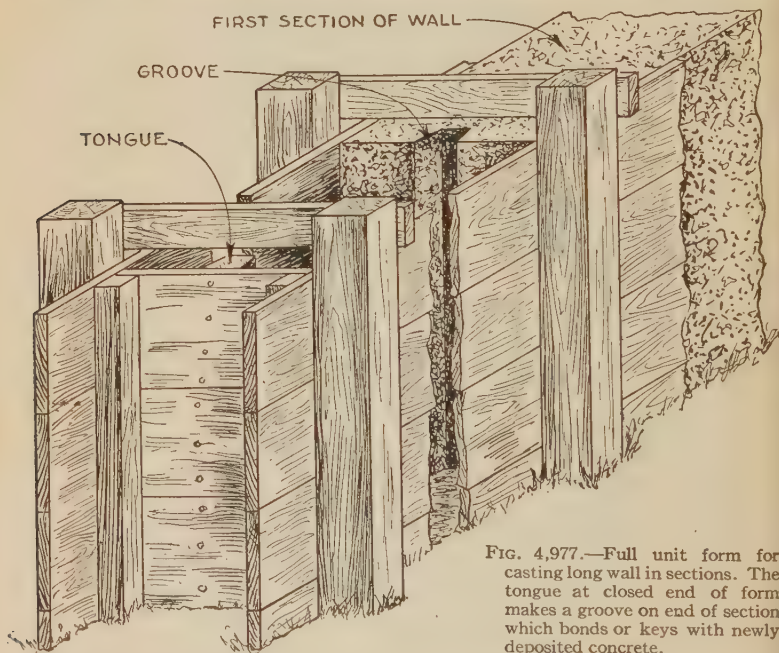


FIG. 4,977.—Full unit form for casting long wall in sections. The tongue at closed end of form makes a groove on end of section which bonds or keys with newly deposited concrete.

ground on both sides. With through braces and spacers as in fig. 4,976, the form is self-supporting, the through braces preventing spreading or bulging, and the spacers, keeping the two sides of the form at the exact distance apart.

To economize lumber, the wall may be progressively built in sections, using a full unit form extending from bottom to top of the wall as in fig. 4,977.

This permits a long wall to be built in sections, the same form being used for the different sections. As soon as the first section sets the form is removed and placed in position for the next section. One end of the form fits over the end of the section just cast as shown in the illustration. The other end is closed by a vertical board with a wedge shaped block on the inside to make a

PORTABLE
SELF SUPPORTING
FORM

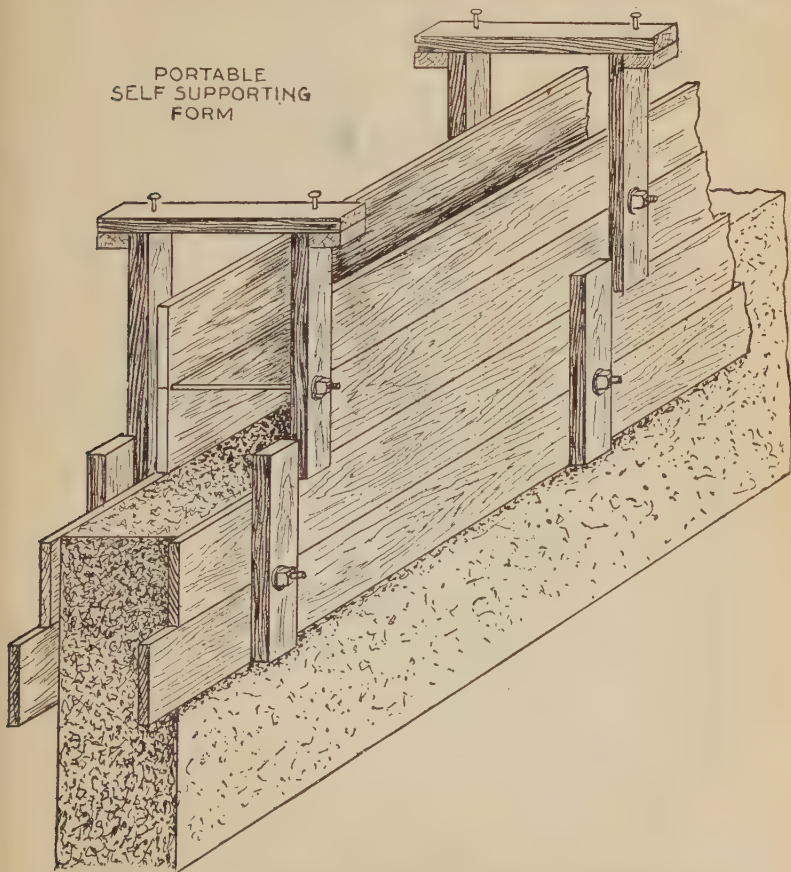


FIG. 4,978.—Layer unit (continuous type) form for building up wall with small amount of lumber.

recess at the end of one section so that the concrete poured for the next section will make a tight joint, keying into the section previously cast.

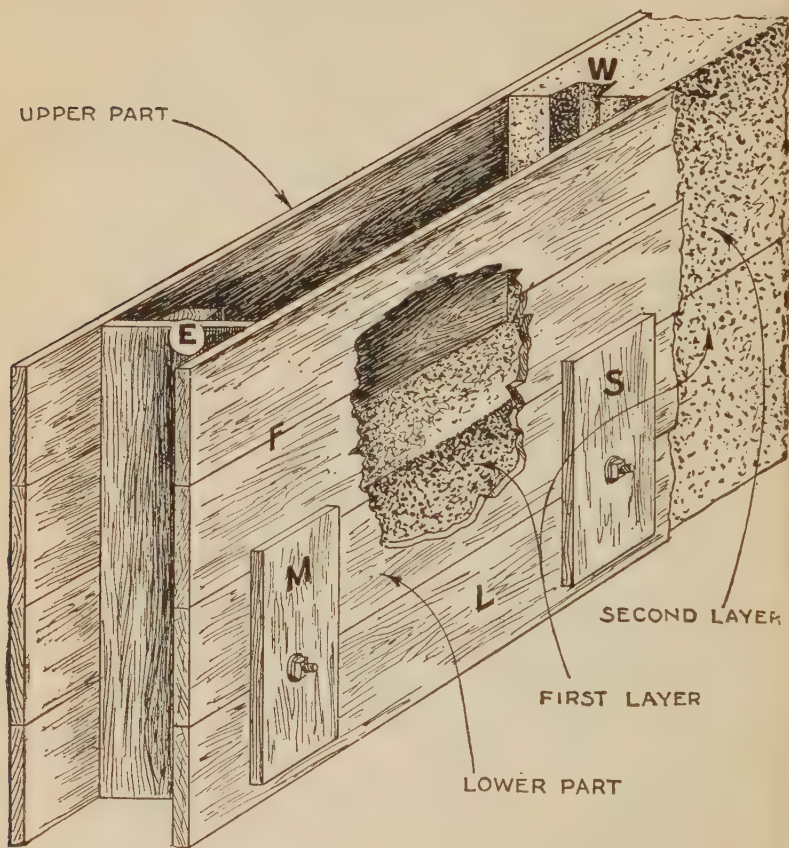


FIG. 4,979.—Layer unit (sectional type) form for building up wall in layer sections with the least possible amount of lumber. The form consists of two parts, an upper and lower. **In operation**, after pouring the lower layer of concrete into part **L**, of the form, the upper part **F**, is placed in position as shown, being held in alignment by the end of the completed section of wall and the guides **E** and **W**. The through bolt braces **M** and **S** should be thoroughly greased so they can be removed easily from the concrete.

When lumber is expensive, or to reduce the amount required the layer unit type of form may be used as shown in fig. 4,978.

The illustration shows the method of applying in building up the wall in successive layers. In case of a long wall or where it is required to use the least possible amount of lumber the sectional type of layer unit form may be used as shown in fig. 4,879. This, as seen, is virtually a modification of the full unit form permitting sections to be built up in layers.

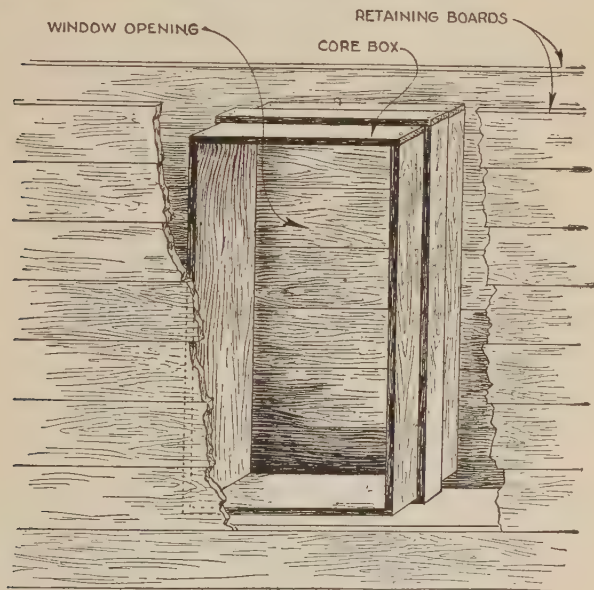


FIG. 4,980.—Core box placed in wall form for window opening.

The method of providing opening in walls for windows is shown in fig. 4,980.

Forms for Rectangular Piers and Columns.—These are simply boxlike forms open at the ends and suitably braced. They are of two general types:

1. Continuous
2. Sectional

The continuous form extends from the bottom to the top of the pier or column and is non-adjustable being suitable for a short pier or column. In constructing such forms, it should be slightly tapered so that it can be lifted off the concrete after the latter sets.

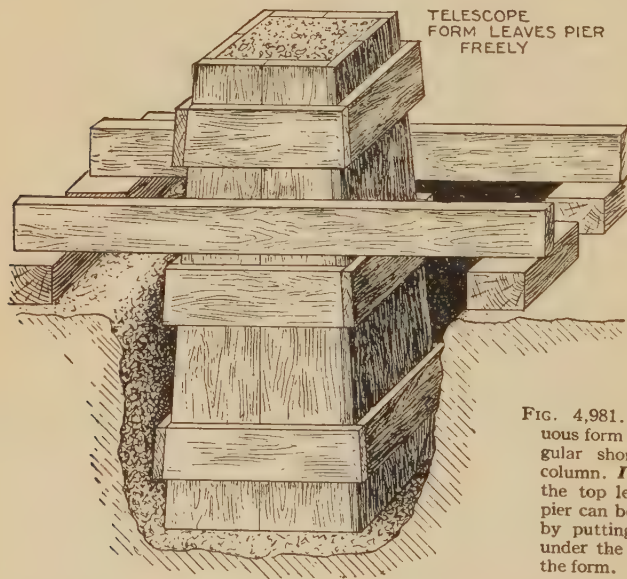


FIG. 4,981. — Continuous form for rectangular short pier or column. *In placing*, the top level of the pier can be regulated by putting blocks under the handles of the form.

Fig. 4,981, shows a continuous pier form measuring inside 10 or 12 ins. on each side at the top and a little more at the bottom.

Larger columns, because of the great pressure near the bottom due to the weight of the concrete, must have more substantial forms, especially if cast in one pouring with continuous type forms.

Very heavy forms may be avoided by building up the column

in several sections, using sectional forms. Owing to using the form several times for the several sections, it is held together by bolts and side pieces held in position by wedges as shown in fig. 4,982.

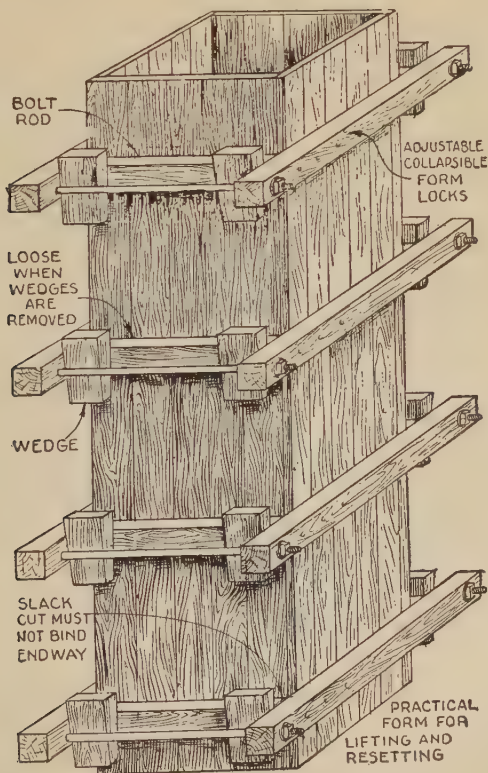


FIG. 4,982.—Sectional form for long rectangular column, having through bolt braces threading through yokes, and wedge adjustment.

After pouring one section, the form can usually be taken off within one to two days, and the form taken off and reset for the next section. For tapered columns, the reduction in the size of the column is obtained by

taking off a strip along one edge of the sides which do not have the yokes projecting and by taking a strip off one of the boards on the sides having projecting yokes. New bolts are either bored in the yokes, or packing strips are placed on the yokes for the wedges to bear against. If there be a boring machine on the job, the yokes should have a series of holes bored in them before they are fastened to the column sides, so that it will not be necessary for the carpenters to bore them by hand.

Forms for octagonal columns are made as shown in fig. 4,983. This column is identical with the one shown in fig. 4,982, except that pieces are inserted in the corners to give the column eight sides. The flare is made at the top of the column by fitting in triangular pieces of wood. Since fresh concrete is practically liquid and over twice as heavy as water, the column

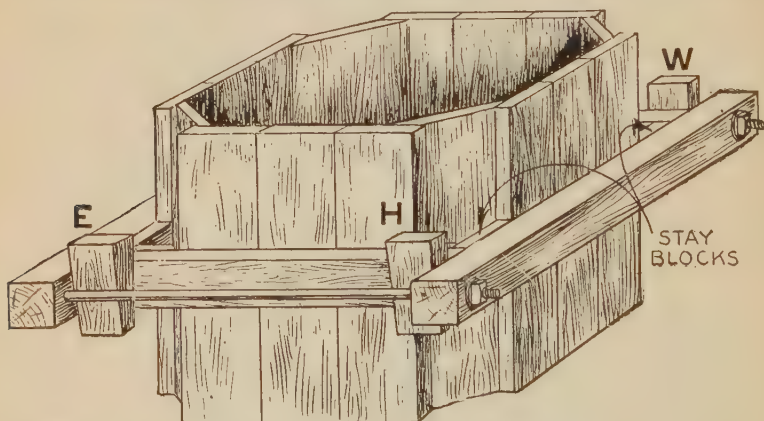


FIG. 4,983.—Detail of form for octagonal column **E**, **H** and **W**, are wedges.

form must be designed to withstand the bursting pressure of the concrete. This will make it necessary to have the yokes closer together at the bottom than at the top.

In place of bolts, rods with a malleable iron clamp fastened in place with a set screw are often used for form work. These clamps may be obtained from supply houses. The clamp is slipped over the rod and brought to a firm bearing by a device furnished by the makers of the clamps. Then the set screw in the clamp is tightened, holding the clamp in place.

A method of clamping columns by using a chain is shown in fig. 4,984.

The chain is hooked around the column as tight as possible and the slack taken up with the wedges.

Spacing of Yokes for Columns.—The accompanying table will be found useful in proportioning columns of various sizes.

Spacing of Yokes for Columns

HEIGHT	LARGEST DIMENSION OF COLUMN IN INCHES							
	16	18	20	24	28	30	32	
1	↑	↑	↑	↑	↑	↑	↑	↑
2	31"	29"	27"	23"	21"	20"	19"	17"
3	—	—	—	23"	21"	20"	19"	17"
4	31"	28"	26"	—	—	—	—	17"
5	—	—	—	23"	20"	19"	18"	—
6	—	—	26"	—	18"	18"	17"	15"
7	30"	28"	—	22"	—	—	13"	12"
8	—	—	24"	—	15"	18"	12"	11"
9	—	26"	—	16"	13"	12"	10"	10"
10	29"	—	19"	14"	12"	12"	10"	8"
11	—	20"	—	13"	10"	10"	8"	7"
12	21"	—	16"	13"	10"	9"	8"	7"
13	—	18"	—	12"	9"	8"	8"	7"
14	20"	—	15"	11"	9"	8"	7"	6"
15	—	16"	—	10"	9"	8"	7"	6"
16	18"	15"	12"	9"	8"	7"	6"	—
17	15"	13"	11"	9"	8"	7"	6"	—
18	—	12"	10"	8"	7"	6"	—	—
19	14"	12"	10"	8"	7"	6"	—	—
20	13"	11"	10"	8"	7"	6"	—	—
	13"	11"	10"	8"	7"	6"	—	—
	12"	11"	9"	8"	7"	6"	—	—
	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—

The method of using the table is illustrated in the following example:

Example —To find spacing of yokes for a 24×18 column 10 ft. high, use column headed 24". Read up column from 10 ft. line and the spacing of yokes will be found to be 14" for bottom yoke, 16" for next upper yoke, 22" for next and so on to top.

Forms for Concrete Roofs.—Since concrete weighs from 130 to 150 pounds per cubic foot, floor and roof forms particularly must be designed with a sufficient factor of safety to prevent

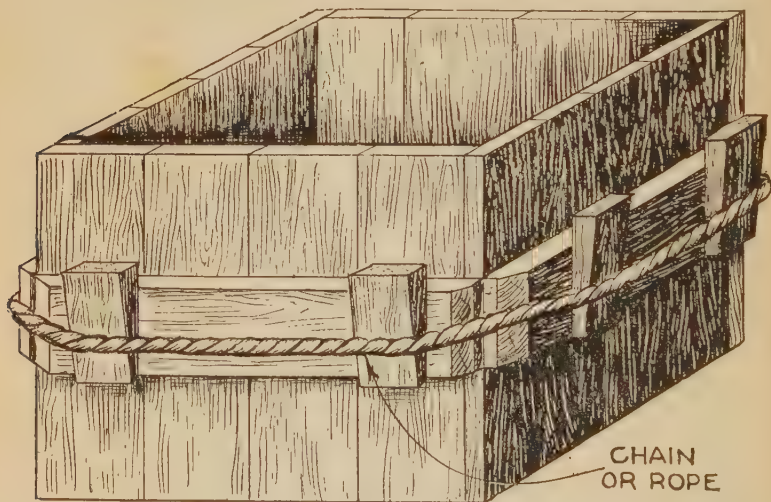


FIG. 4,984.—Detail of form for rectangular column showing method of clamping by means of a chain or rope and wedges.

them from sagging from their own weight as well as that of the concrete. Any sagging of forms will result in small cracks developing while the concrete is hardening, and these will gradually widen, preventing the construction having the desired strength. Enough braces, struts and studs must be used to prevent forms sagging.

Accordingly substantial bracing should be used.

Forms for roofs should not be removed in less than three weeks. It is very important that roofs have plenty of time to set before they are used.

Circular Forms.—These are of two types: movable and stationary.

The forms are generally laid out on a floor, or level piece of ground, by means of a stake at the center and the use of a compass stick with holes at end, the distance between being equal to the radius of the circle. The hole at one end is used for fastening the stick to the stake and the hole at the other end is for a pencil to mark the circle.

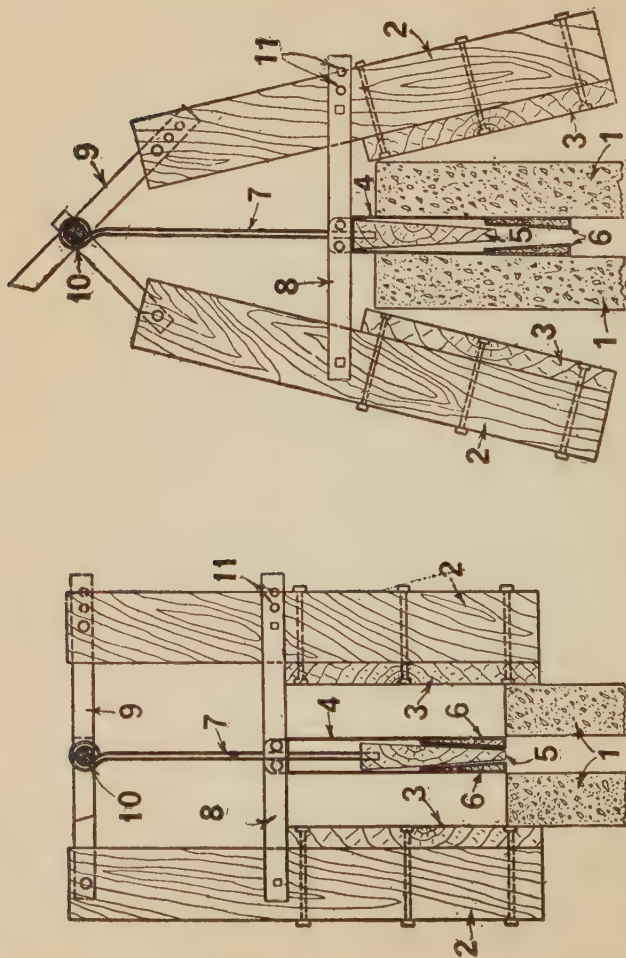
In constructing tall tanks or silos, the forms are wedged in place and filled with concrete. When the concrete is sufficiently hard the wedges are loosened and the forms raised, guided by the uprights and wedged in place and again filled.

Movable forms work very advantageously on certain classes of work, such as silos and grain tanks.

In some classes of work, such as large water towers where the concrete is poured fairly wet, movable forms are not used to good advantage on account of the time required for the concrete to harden properly before raising the forms.

If the builder be doing very much tank, elevator, or silo construction, he usually finds a set of steel forms to represent economy.

Double Forms.—In concrete house construction, when a solid wall is made, it is a simple matter to set up an outside and an inside form of suitable lumber set in the right position and place, plumbed and braced. However, to economize material and obtain the advantage of air core insulation, double or hollow core forms are used. The demand for hollow concrete walls has developed the double forms some of which have been patented.



FIGS. 4,985 and 4,986.—Frost double hollow wall forms in closed and open or releasing position. In the illustrations, the parts are: 1, section of cast wall; 2, stud reinforcement; 3, outer boards; 4, upper end of inner or core metal plate; 5, wedge end of core plate; 6, wedge blocks; 7, lifter rod; 8, pivot rod; 9 and 10, links; 11 pivot holes.

Figs. 4,985 and 4,986 show an improved type of double forms in closed and open or releasing positions.

Assuming that the average size of the building is $25 \times 50'$, three laborers can pour or fill, in one day an 18 inch course and set the reinforce bars so that the work may proceed promptly the next day. There should be no attempt made to have the walls smooth. The rough texture gives better adhesion of the finish coatings to be applied.

An 8 in. hollow wall with a 2 in. air space is one-quarter lighter and requires one-quarter less material than if poured solid; it, also, saves the need of damp proofing and furring the inside wall for plastering.

The accompanying cuts show construction of beam, girder and flat slab forms, etc.

The following tables give the sizes of posts, stringers and joists for flat slab forms:

NOTE.—*Pointers on Forms and Their Use.* Concrete will not stick to forms that are oiled each time before use with a mixture of boiled linseed oil and kerosene, equal parts of each, but if not so oiled they should at least be thoroughly wetted down. They should be carefully cleaned of all particles of adhering concrete after removal and be wet down immediately before again placing concrete in them. Forms for the ordinary types of square or rectangular stock watering troughs, hog feeding troughs, manure pits, are all of a simple type, and when the earth is firm enough to be self-sustaining only an inside form will be necessary. Otherwise, form construction simply amounts to one frame within another; that is, two bottomless boxes of different sizes, one set inside of the other. Forms for square or rectangular tanks that are to be built above ground should provide for a batter or slope on the inside of the structure so that the expansion from freezing water will be spent upward instead of against the tank sides. For such tanks as cisterns, which are usually placed wholly underground, of course a form is needed for the cement roof or cover slab. This is in the nature of a floor supported by studs.

NOTE.—There is no possibility of stating with precision the time when forms may safely be removed from any piece of construction. This varies entirely with weather conditions and the mass of concrete. Whenever the structure is one which need support no weight but its own, such as a building wall of medium dimensions, all above ground, forms can sometimes be removed in three or four days. There is no advantage however, in removing forms too early because the forms afford desirable protection to the concrete in preventing it drying out too rapidly and also prevent a too rapid radiation of the chemical heat generated by the set of the cement. Forms for heavy arches, for floors supported above ground and roofs, must all be left in place from ten to two, three or four weeks. It is a wise plan to leave forms in place a few days longer than may seem absolutely necessary, just to be on the safe side. Such a precaution often marks the difference between failure and success.

Table

Various thicknesses of slabs referred to in Tables on pages 608, 609, 611 and 620 by Number

Slab No.	Slab Thickness in Inches of Solid Concrete Slab	Combination Tile and Concrete Slab	Slab No.	Slab Thickness in Inches of Solid Concrete Slab	Combination Tile and Concrete Slab
1.....	3	.....	10.....	7	13
2.....	4	6	11.....	.....	14
3.....	.....	7	12.....	8	.....
4.....	.....	8	13.....	.....	15
5.....	5	.....	14.....	9	.....
6.....	.....	9	15.....	10	.....
7.....	.....	10	16.....	11	.....
8.....	6	11	17.....	12	.....
9.....	.....	12	.....	.....	.....

Table

Posts for centering

3×4 in. solid, to be spaced 4×6 ft. or less, under slabs 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 braced in four directions every 7 ft.; and to be spaced 4×4 ft. or less under slabs 11, 12, 13, 14, 15, 16, 17 and 4 ft. apart under girders or beams.

4×4 in. solid, or T-post of two 2×4 in. properly spiked, to be spaced 6×6 ft. or less under slabs 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, braced in four directions every 8 ft.; and to be spaced 4×6 ft. or less under slabs 11, 12, 13, 14, 15, 16, 17 or 5 ft. apart under girders or beams.

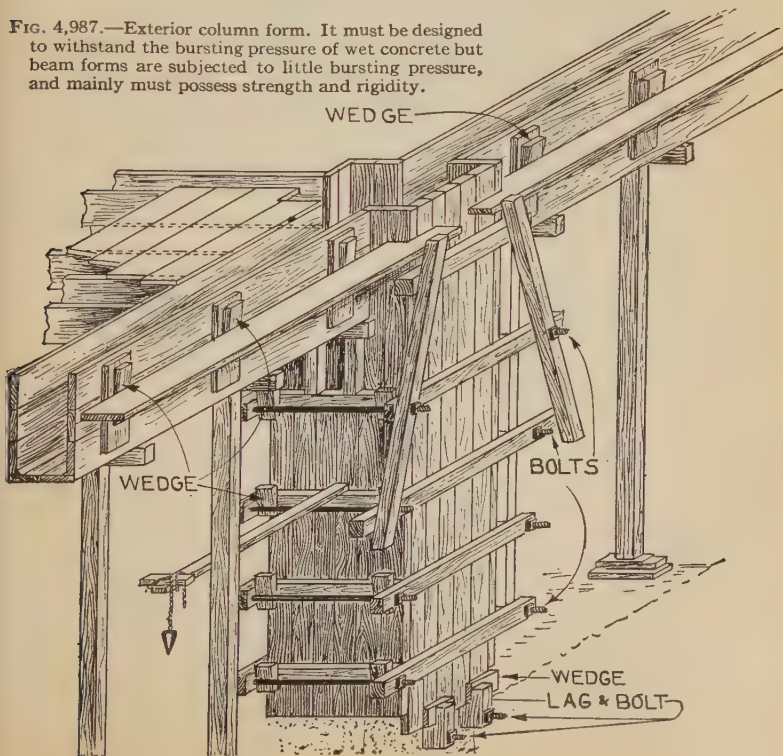
6×6 in. solid, or T-post or 2×4 in. and 2×6 in., properly spiked, braced in four directions every 8 ft. and to be spaced 6×6 ft. or less under slabs 12, 13, 14, 15, 16, 17 or 6 ft. apart under girders or beams.

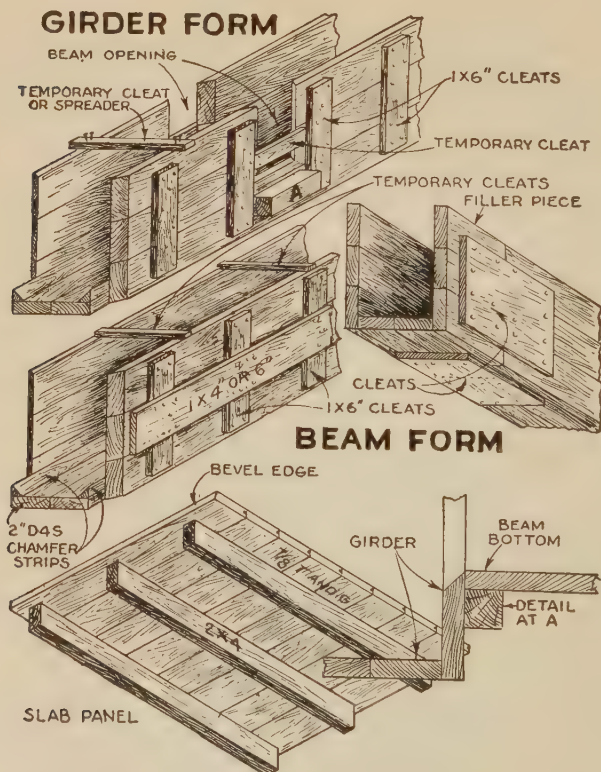
Table

Size and spacing of joists and 4 foot spans

Slab No.	Size	Spacing	Slab No.	Size	Spacing
	Inches	Inches		Inches	Inches
1.....	2×4	16	16.....	2×6	21
	2×6	24	17.....	2×6	21
2 to 15 incl.	2×6	24			

FIG. 4,987.—Exterior column form. It must be designed to withstand the bursting pressure of wet concrete but beam forms are subjected to little bursting pressure, and mainly must possess strength and rigidity.





Figs. 4,988 to 4,992.—Girder beam and slab form construction for use when the forms are removed entirely as a unit. Figs. 4,988 and 4,989, beam form; figs. 4,990 and 4,991, girder forms, fig. 4,992 slab panel. **The material** for the beams and girders is 2 in. stock dressed on all sides. It shall be as wide as possible, making the bottom in one piece to avoid the necessity of cleats across the bottom, which are objectionable in handling due to their catching on obstructions. The beam bottom should be the width of the beam and the sides should lap over the bottom. The side cleats are 1X6 material, spaced about 3 ft. apart. The sides are fastened to the bottom by nailing. Along the cleats is nailed a 1X4 piece to support the spreaders of the floor panels. The cross pieces shown on top are tacked on when the form is being handled to prevent the sides caving in.

Table

Size and spacing of joists on 6-foot spans

Slab No.	Size	Spacing	Slab No.	Size	Spacing
	Inches	Inches		Inches	Inches
1, 2.....	2×6	16	7, 8... ..	2×6	12
	2×8	24		2×8	24
3.....	2×6	15	9, 10, 11,	2×6	12
	2×8	24	12, 13	2×8	21
4, 5, 6....	2×6	14	14, 15,	2×8	21
	2×8	24	16, 17	2×10	18

Table

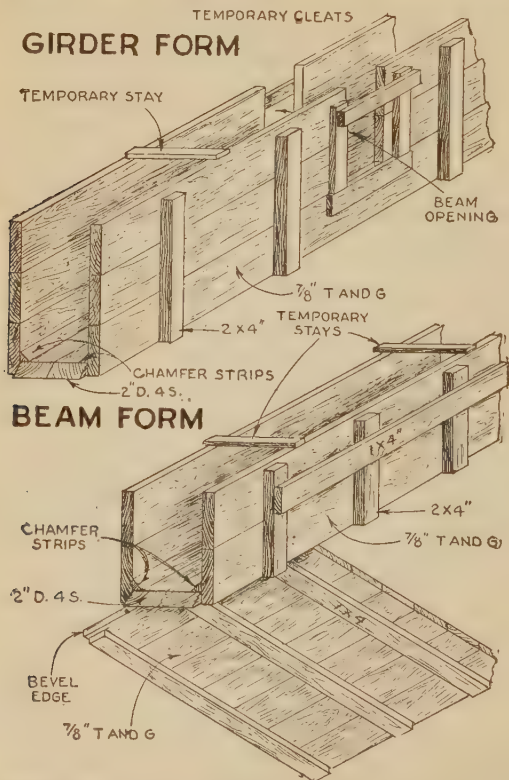
Section Sizes for Circular Forms of Various Diameters and Quantities

Inner Form					Outer Form
Inside Diam.	Number of Sections in Inner Form	Length A	Length B	20-Gauge Gal. Iron 36 in. wide, Length of Each Piece	18-Gauge Gal. Iron 36 in. wide, 2 Pcs. Length of Each Piece
10 ft.	6	5'- 0"	4'- 7½"	5'-2¼"	18'- 3"
12 ft.	8	4'- 6¾"	4'- 1½"	4'-8½"	21'- 5"
14 ft.	8	5'- 4"	4'-11½"	5'-6"	24'- 7"
16 ft.	8	6'- 1"	5'- 9½"	6'-3"	27'- 9"
18 ft.	8	6'-10½"	6'- 7½"	7'-0¾"	30'-10½"
20 ft.	10	6'- 2"	5'-10"	6'-3"	34'- 0"

Material for 14-Foot Silo Form

- 5 pieces 2 by 12 by 16 feet, for ribs.
- 1 piece 2 by 12 by 6 feet, for ribs.
- 4 pieces 2 by 6 by 12 feet, for studding.
- 6 pieces 2 by 4 by 12 feet, for studding.
- 4 pieces 2 by 6 by 10 feet, for connections.
- 3 pieces 2 by 6 by 8 feet, for continuous door form.
- 2 pieces 2 by 2 by 8 feet, for continuous door form.
- 64 pieces ½ by 4½ inch carriage bolts.
- 2 pieces 18 gauge galvanized iron 3 feet wide, 24 feet 7 inches long.
- 8 pieces 20 gauge galvanized iron 3 feet wide, 5 feet 6 inches long.
- Nails, rivets, lugs, hooks, wedges, etc.

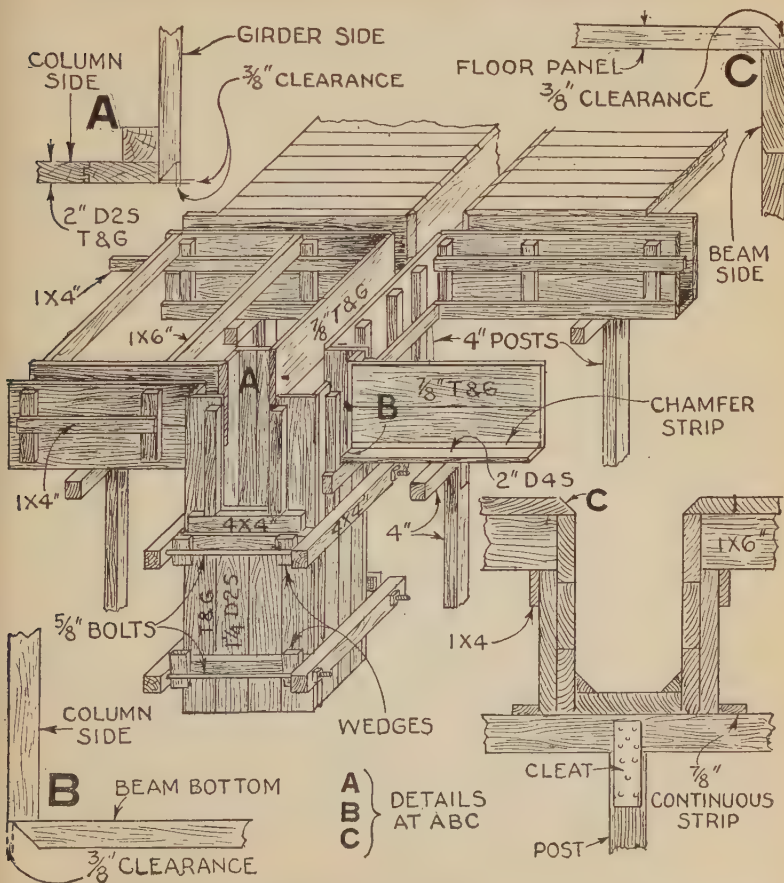
Stripping.—After the concrete has hardened the forms must be removed, hence they must be constructed so they can be removed without injury to the concrete and, if they are to be used more than once, without injury to themselves.



FIGS. 4,993 to 4,995.—Beam, girder and slab form construction; types for use when beam and girder bottoms remain in place on shoring posts, after sides are removed.

The stripping order of beam and girder forms in which bottoms remain in place after the sides are removed is as follows:

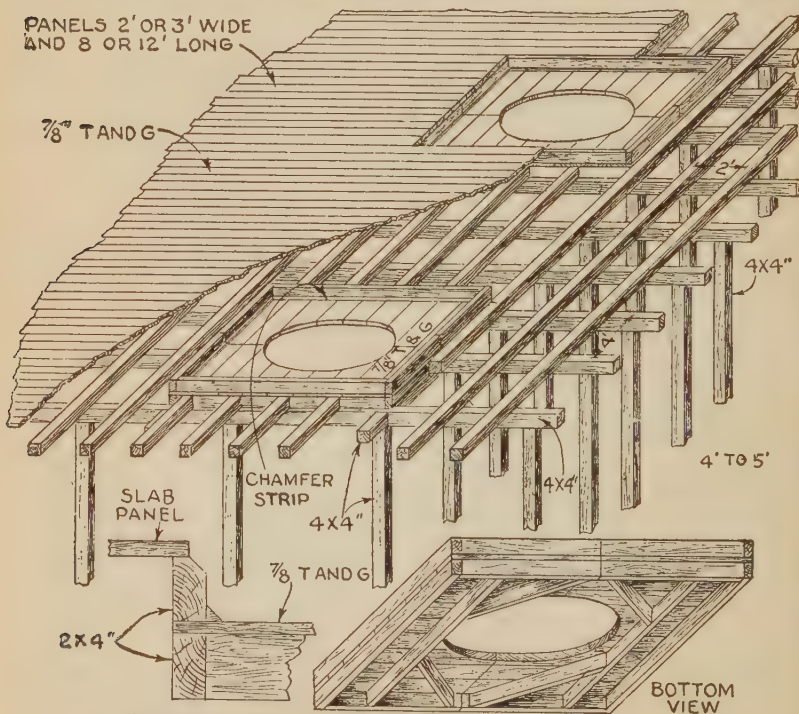
1. Remove column wedges
2. Remove column bolts
3. Remove column sides
4. Remove strips holding lower edge of beam and girder sides



FIGS. 4,996 TO 5,000.—Beam and girder construction showing assembled forms on which the bottoms of beam and girder forms will remain in place after sides are removed, and details of various parts.

5. Remove floor panel purlins
6. Remove girder sides
7. Remove beam sides
8. Remove slab panels
9. When floor has gained sufficient strength the beam and girder bottoms are removed with the shoring posts.

The column sides are first removed. After removing the blocking between the column yokes and the beam bottoms, and the key pieces between the column sides and beam sides, of the type shown in figs. 4,996 to 5,000, the



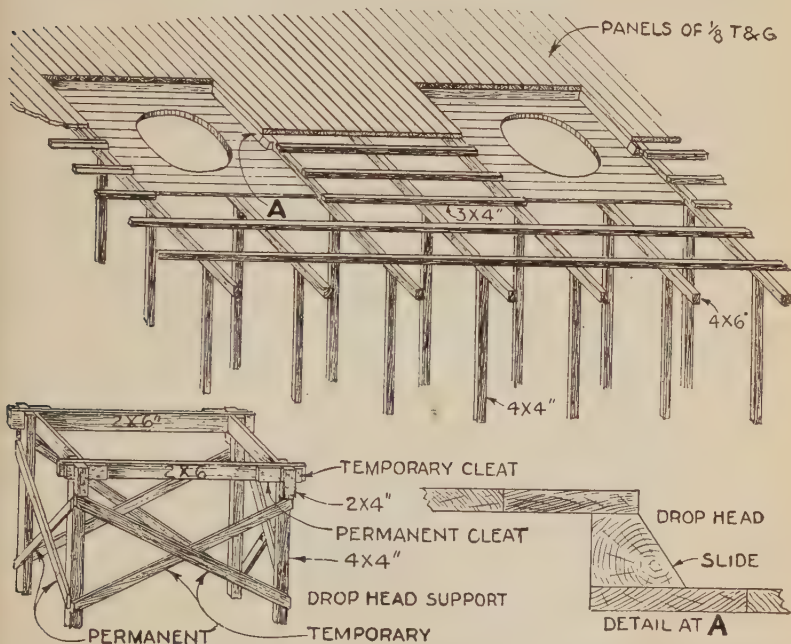
SECTION AA

BOTTOM VIEW

FIGS. 5,001 to 5,003.—Flat slab form construction showing depressed heads resting directly on stringers. *They are made in two sections for ease in handling.* The column forms are built up either in wood or steel and have no part in supporting the slab forms. The slab panels are $\frac{7}{8}$ in. tongue and groove stock made up in sections about 5 ft. long by 2 ft. wide.

bottom of the column form should be pried loose. After being moved out for 6 to 8 ins., the column side will come free at point B, and the space occupied by the key piece will give room enough to allow the column side to be removed.

In the type shown in figs. 5,007 to 5,011 the column sides will slide by the beam forms without the removal of the key pieces.

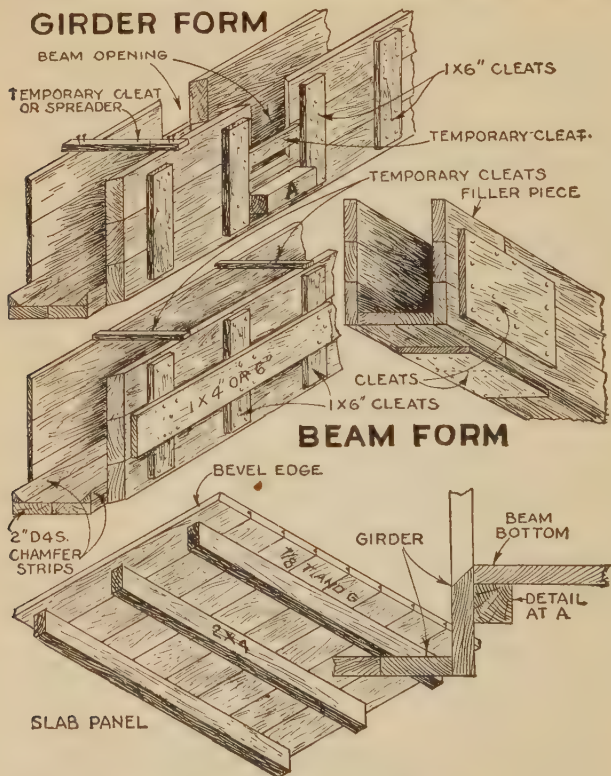


FIGS. 5,004 to 5,006.—Flat slab construction—alternate forms, depressed heads on separate frames so that it can be easily taken apart and re-erected. The posts are 4×4 and carry 4×4 stringers. On these stringers are laid 3×4 cross pieces to hold the floor panels. These panels are made the length between column centers and about $\frac{1}{4}$ the width the side of the depressed head is formed by a piece nailed to the floor panels, allowing more leeway if columns be not exactly centered.

Next the purlins are removed unless they form the panel cleats. This can best be done from a scaffold on horses. It is

then necessary to remove the girder forms. As these are heavy the best method is shown in figs. 5,012 to 5,015.

The rig consists of four 44×4's used in pairs. The sticks are cut a little longer than the height between the floor and ceiling



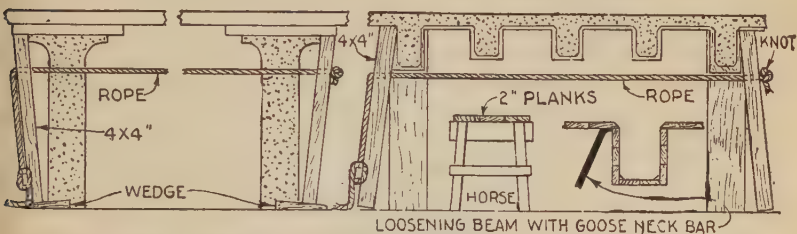
FIGS. 5,007 to 5,011.—Assembly of beam and girder forms of the kind which are to be completely removed as a unit.

slab through the upper end, at a point just below the girder forms, are bored holes to take a 1 in. rope. This is knotted against one of the sticks to which is nailed a cleat.

The sticks are then erected with the bottoms wedged tight as shown in fig. 5,014, and the rope pulled taut and fastened to the cleat.

The girder shores are then removed. If the girder form stick, it can be readily loosened by using goose neck bars as shown in fig. 5,015. The girder forms are then dropped on to the ropes and lowered to the floor by releasing the ropes from around the cleats. The girder shores are then replaced, the same operation is used in stripping the beam and slab forms.

The same general method is used in stripping beam and



LOOSENING BEAM WITH GOOSE NECK BAR

FIGS. 5,012 to 5,015.—Methods for stripping flat slab and girder and beam forms. Fig. 5,012 and 5,013 stripping rig for flat slab forms, figs. 5,014 and 5,015 stripping rig for beam and girder forms.

girder forms where the beam and girder bottoms are left in place.

In this case, the continuous strip on top of the posts is first removed, and then the beam and girder sides are pried loose, falling onto the ropes.

A similar rig is used for stripping flat slab forms as shown in fig. 5,012. The sticks are cut a little longer than the story height with the result that any weight on the ropes serves to wedge the sticks together. In stripping the flat slab forms the permanent shores should be placed before the form shores are removed. In order that the panels can be removed when the permanent shores are in place, a small section of the panel is left loose along the joint where the shore is to go. This is shown

in fig. 5,016. Then the stripping rig is erected and the shores, longitudinal and cross stringers removed and the floor slabs pulled down.

In the type of forms shown in figs. 5,001 to 5,003, the forms for the depressed heads are removed at the same time as the slab panels, while in figs. 5,004 to 5,006, the scaffold holding the depressed head forms is removed first.

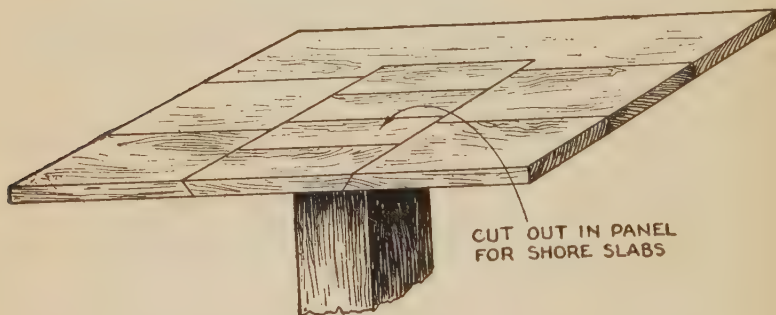


FIG. 5,016.—Cut out in panel for shore slab.

The main features of this stripping rig is that *the forms are not injured in stripping* and if, when removing the shores some beam or slab panel should fall, the workmen will not be injured, as the forms will be caught by the ropes.

Greasing Forms.—The object of greasing wood forms is to waterproof the wood and to prevent it absorbing the water in

the concrete, causing swelling and warping; also, to leave a thin skin of the grease on the surface of the forms to prevent concrete entering the pores of the wood and adhering to it. Forms should be thoroughly swept before the reinforcement is placed and kept clean until the concrete is poured.

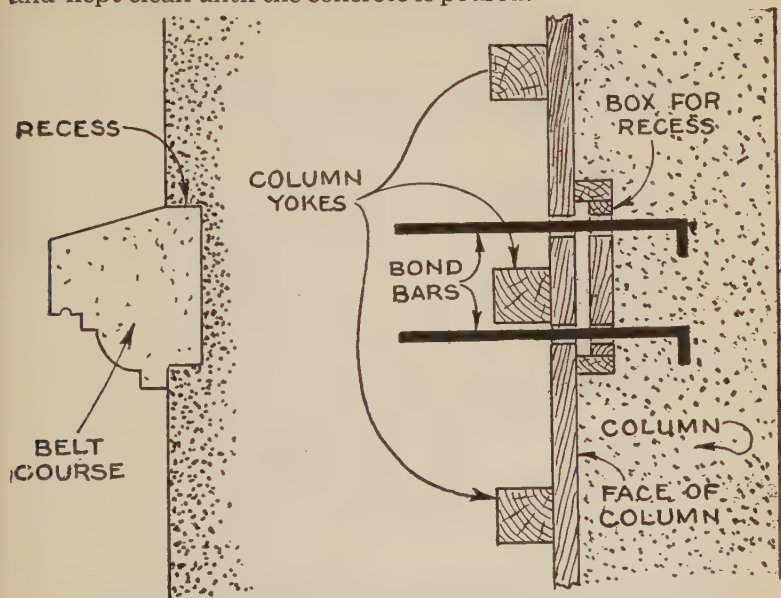


FIG. 5,017.—Relation between belt course and recess provided for it. The recess is 2 in. deep the full width of the column, and with a vertical dimension about 2 in. less than the overall vertical dimension of the belt course or cornice, to allow the bottom of the belt course to conceal the joint with the bottom of the recess, which would otherwise be visible, particularly if all the recess boxes were not set at the same level.

FIG. 5,018.—Vertical section through column form showing recess box in place against face of forms.

If there be dirt or sawdust on the wood, the grease will cover this and not coat the surface of the wood. The most satisfactory greases are the mineral oils and paraffins. Crude or fuel oil is the cheapest and is satisfactory. It is, however, too thin except in cold weather, and is best mixed with petroleum grease

such as unrefined vaseline. The crude or fuel oil is mixed with this grease in the proportion of one part grease to 3 or more parts oil, the proportion varying according to temperature, more grease being required in warm weather.

For metal forms the cheapest and best grease is plain crude or fuel oil without the addition of grease. Cold water paint can be used satisfactorily.

CHAPTER 90

Reinforced Concrete

By definition, *reinforced concrete is concrete tied together by a system of metal rods or bars.*

In the proposed standard regulations of the American Concrete Institute, reinforced concrete is defined as "*an approved mixture of Portland cement with water and aggregates in which metal (generally steel) has been embedded in proportionately small sections in such a manner that the metal and the concrete assist each other in taking stress.*"

Since the tensile strength of concrete is very much less than its compressive strength it follows that to support a given load by concrete in tension would cost about 6 times as much as to support it with steel.

Hence if the various members of a structure be so designed that all of the compressive stresses are resisted by concrete and steel is introduced to resist the tensile stresses, each material will be serving the purpose for which it is cheapest and best adapted and one of the principles of economic design will be fulfilled.

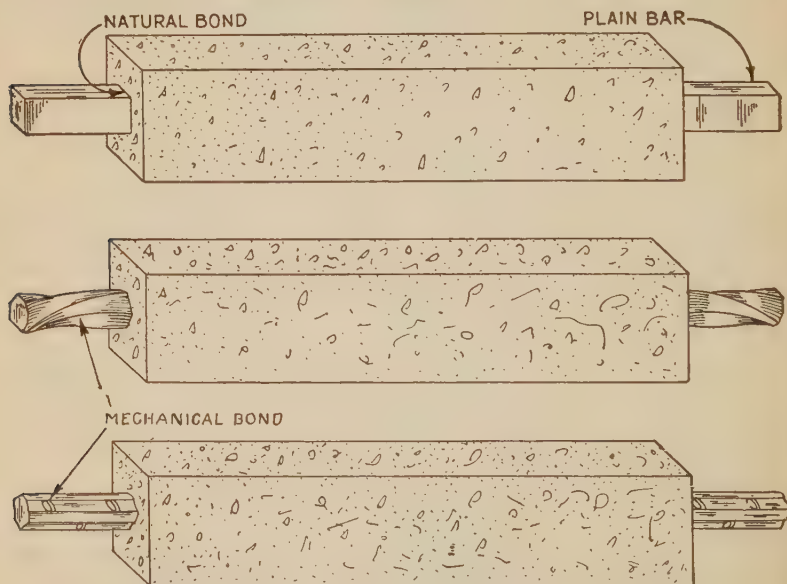
Bond Between Concrete and Steel.—The bond between the

NOTE.—*The compressive strength of concrete* is about 10 times its tensile strength while steel has about the same strength in tension as in compression. Volume for volume steel costs about 50 times as much as concrete. For the same sectional areas steel will support in compression 30 times more load than concrete, and in tension 300 times the load that concrete will carry. Hence for duty under compression only concrete will carry a given load at $\frac{1}{40}$ of the cost required to support it with steel.

concrete and the surface of the metal reinforcement is of two kinds.

1. Natural.
2. Mechanical.

The natural bond is that bond between the surface of the steel reinforcement due to adhesion and shrinkage of the concrete during the process of setting or hardening which causes



FIGS. 5,019 to 5,021.—Distinction between *natural* and *mechanical* bond in reinforced concrete.

the concrete to firmly grip the metal. Mechanical bond is an additional grip due to twisting or deforming the metal as exemplified by twisted and deformed reinforcing bars. The distinction between the two kinds of bonds is shown in figs. 5,019 to 5,021.

Types of Reinforcement.—Steel reinforcement for reinforced concrete may be obtained in a multiplicity of shapes and may be classed:

1. With respect to the surface, as
 - a.* Plain
 - b.* Twisted
 - c.* Deformed

2. With respect to cross sectional shape, as
 - a.* Round (rods)
 - b.* Square (bars)

3. With respect to kind of reinforcement, as
 - a.* Rods
 - b.* Bars
 - c.* Unit systems
 - d.* Woven wire
 - e.* Welded, or other fabrics
 - f.* Expanded metal
 - g.* Links and rods (column reinforcement)
 - h.* Various patented systems

Rods and Bars.—These are very extensively used for general reinforcing and there is a multiplicity of types of bars on the market as shown in the accompanying cuts. It is contended that the edges of square bars and some other shapes start initial cracks in the concrete as it shrinks in setting. Twisted flat bars when placed too near the surface of the concrete cause a spalling or breaking out of the concrete from between the convolutions when the steel is under stress.

The following table gives the standard sizes of bars regularly carried in stock.

Standard Sizes of Reinforcing Bars

Area in sq. in.	.11	.196		.307	.442	.601	.785	1.	1.27	1.56
Equivalent Bar.	$\frac{3}{8}$ R	$\frac{1}{2}$ R	$\frac{1}{2}$ S	$\frac{5}{8}$ R	$\frac{3}{4}$ R	$\frac{7}{8}$ R	1 R	1 S	$1\frac{1}{8}$ S	$1\frac{1}{4}$ S

Note R indicates round bar and S, square bar.

Unit Systems.—In a unit system the various members comprising each reinforcing unit are assembled and so tied together that they retain their relative positions while the

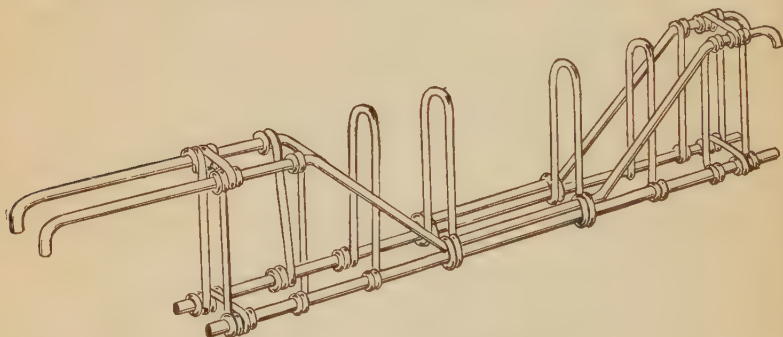


FIG. 5,022.—One unit of a typical unit reinforcing system illustrating the unit method of reinforcing concrete.

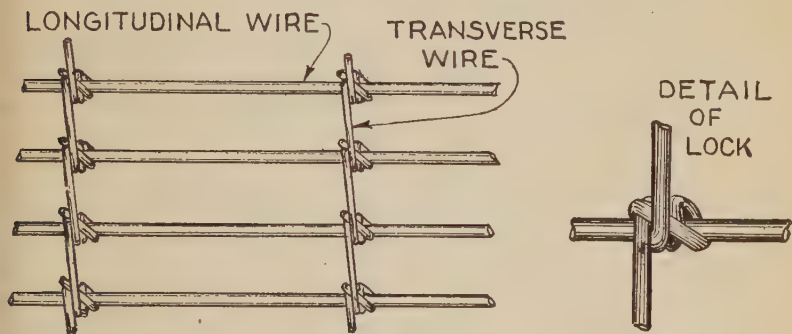
concrete is being poured. Hence after being placed in the form and during the pouring of the cement there is no possibility of the members of each unit shifting their positions.

Fig. 5,022 shows a typical unit. Evidently such units can be thoroughly inspected and checked before being placed in position. Being marked, its exact location is easily determined from the erection plan and after it is put in place a quick inspection will show at once whether it be correctly placed or not, as it must fit and extend the full length of the mould.

Woven Wire.—This reinforcing fabric is made up in rectangular mesh, the usual spacing of the longitudinal wires being

3 ins. on centers and that of the transverse wires 12 ins. on centers. These spacings can be varied to meet special conditions. The fabric is usually made 54 ins. wide and comes in rolls containing from 150 to 600 lineal feet, the 150 ft. length being commonly used. The longitudinal or carrying wires are held in correct spacing by the transverse tie wires as shown in figs. 5,023 and 5,024.

Welded Wire.—As a reinforcement for general concrete construction welded wire fabric, as shown in figs. 5,025 and



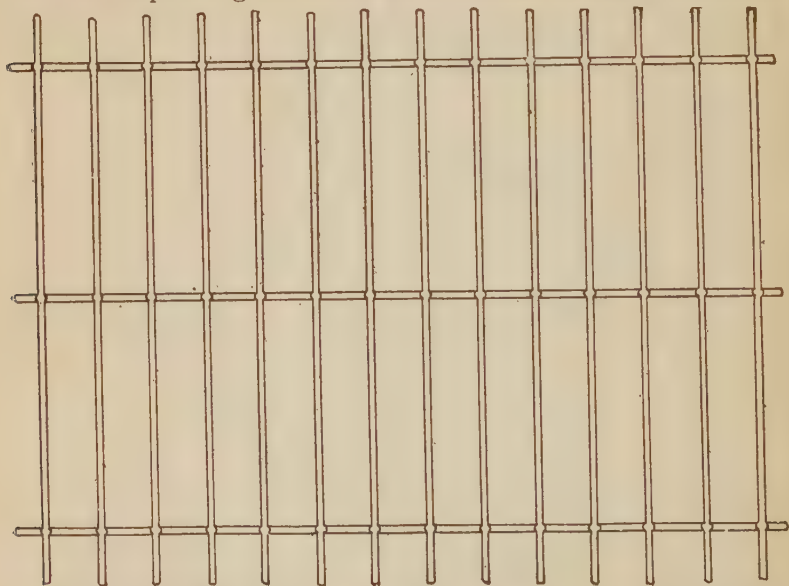
FIGS. 5,023 and 5,024.—Lock woven steel wire and detail of lock.

5,026, is extensively used. The advantage claimed for this wire as a reinforcement for slab construction is that the carrying wires may be varied both in spacing and size to suit any special conditions; the transverse or cross wires may also be similarly. Since the cross wires are welded to the carrying wires, the rigid joints tend to prevent distortion of the rectangular mesh.

The carrying wires commonly used range in size from No. 10 to No. 3 (Washburn & Moen gauge) and are spaced from 1 to 4 ins. centers, the cross wires vary from No. 11 to No. 6 gauge and are spaced from 3 to 12 ins. centers. This fabric is regularly made in long rolls and in widths from 48 to 86 ins.

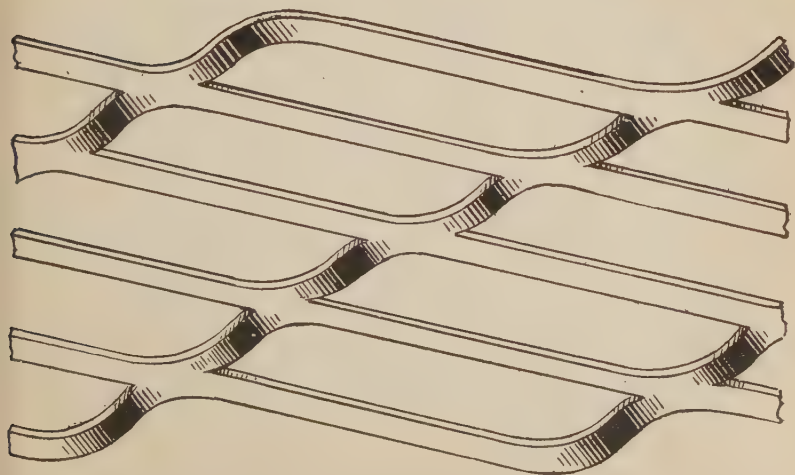
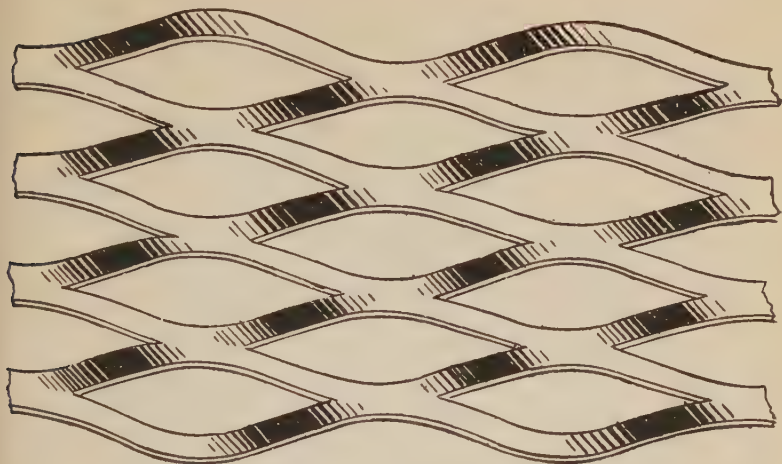
Expanded Metal.—This reinforcing fabric comes in sheets 8 to 16 ft. long and from 3 to 8 ft. wide according to the width of the mesh. It is made from a soft tough steel of fine texture varying in thickness from No. 13 to No. 1 Stubbs gauge. Fig. 5,027 shows the diamond shape mesh used extensively in floor construction.

One method of forming is by slitting a sheet of soft steel and then expanding the metal in a direction normal to the axis



FIGS. 5,025 and 5,026.—Welded wire fabric; side and end views. It is claimed that any elongation of the carrying wires that may occur under stress of heavy load is divided along the carrying wires as often as the cross wires occur instead of being concentrated at one point as in the case with loose rods or wires.

of the sheet. Another type of expanded metal is made from thin strips of soft tough steel by a mechanical process which pushes out and expands the metal into the mesh at the same time reverses the direction of the edge so that the flat surface



FIGS. 5,027 and 5,028 —Expanded metal reinforcing fabric. Fig. 5,027 diamond mesh; fig. 5,028 rectangular mesh.

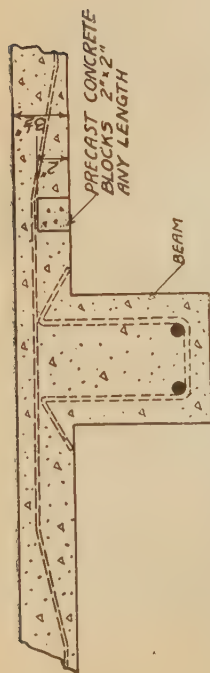
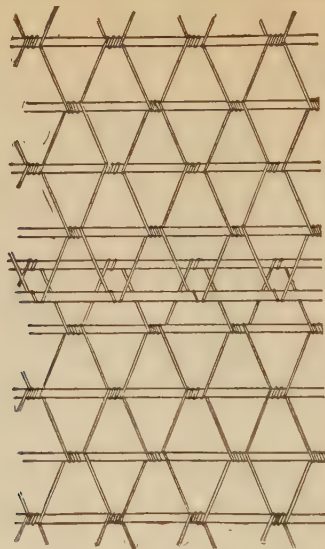
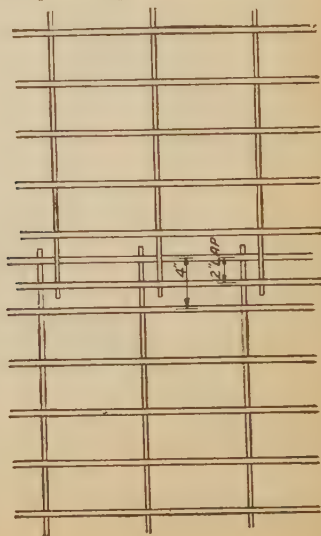


FIG. 5.029.—Inexpensive method of supporting wire fabric reinforcement over concrete beams.



FIGS. 5.030 and 5.031.—American wire fabric as it actually appears with a side lap of 2 ins. Fig. 5.030, triangle mesh reinforcement; fig. 5.031, electrically welded valve.



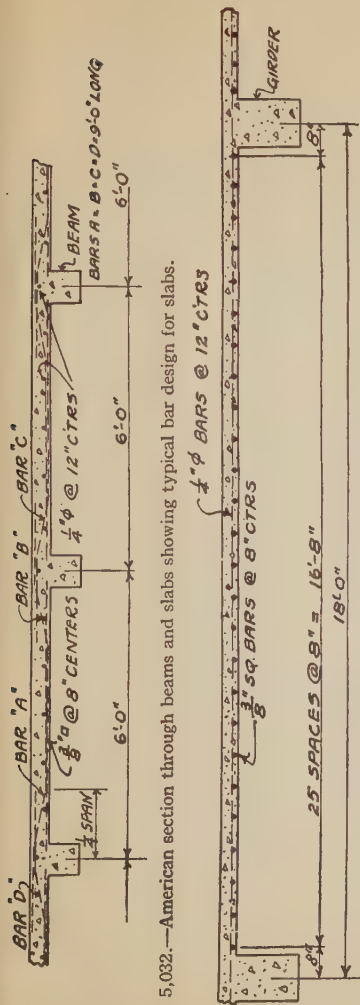


FIG. 5,032.—American section through beams and slabs showing typical bar design for slabs.

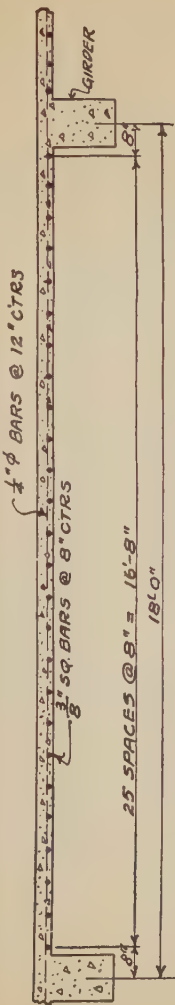


FIG. 5,033.—American section through girder showing typical bar design for slabs.

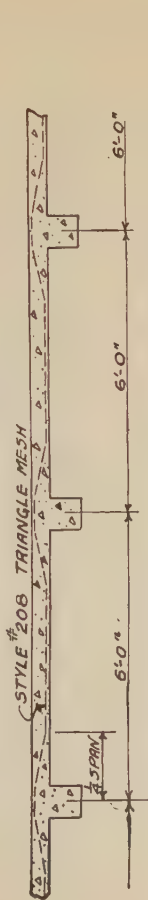


FIG. 5,034.—American section through beam and slabs showing typical mesh design for slabs.

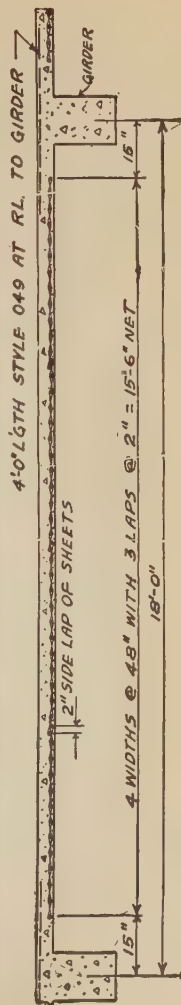
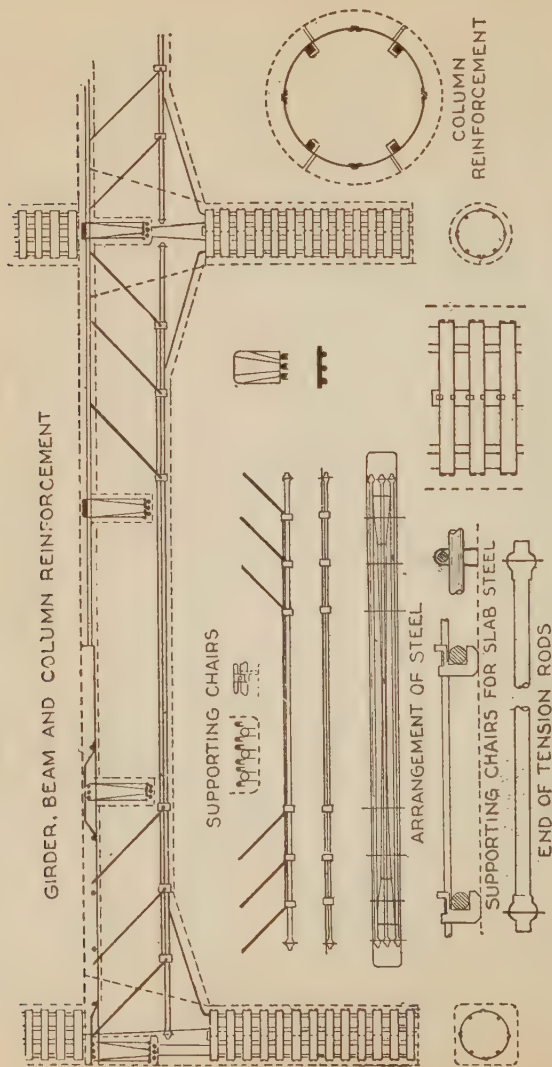


FIG. 5,035.—American section through girder and slabs showing typical mesh design for slabs.



FIGS. 5,036 TO 5,049.—Cummings system and details of construction. In fig. 5,036 is shown the Cummings method of forming the bent up bars and attaching them to the tension bars. In general the plan is to provide tension bars with ends specially anchored, while securely attached to them are small rods horizontal in the middle of the beam or girder, but bent up, as indicated, to pass across the top of the beam and form inclined inverted U-bars or stirrups. The construction is shown more in the detail views.

of the cut strand is nearly at right angles to the general surface of the sheet.

In specifying expanded metal, it is necessary to give the weight of the finished product per sq. yd. as well as the gauge of metal as the strands may be of various widths.

Reinforced Concrete Systems.—Many methods are used to

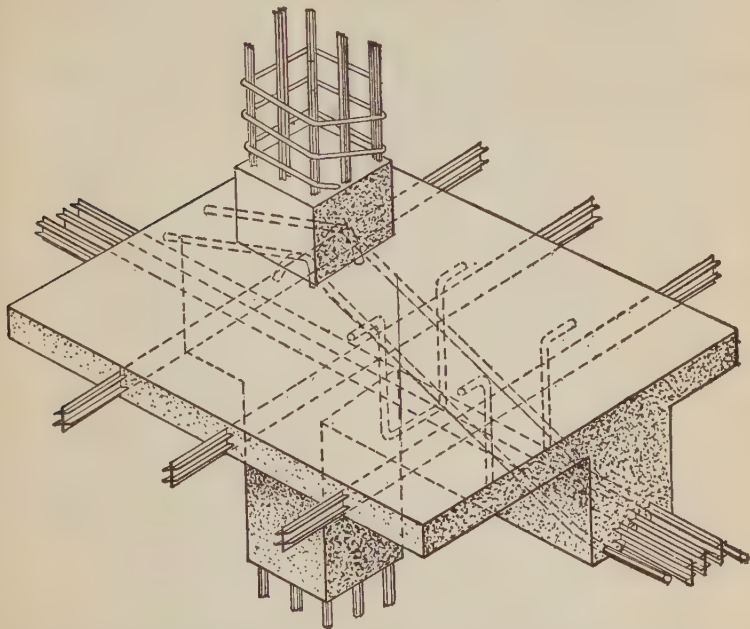
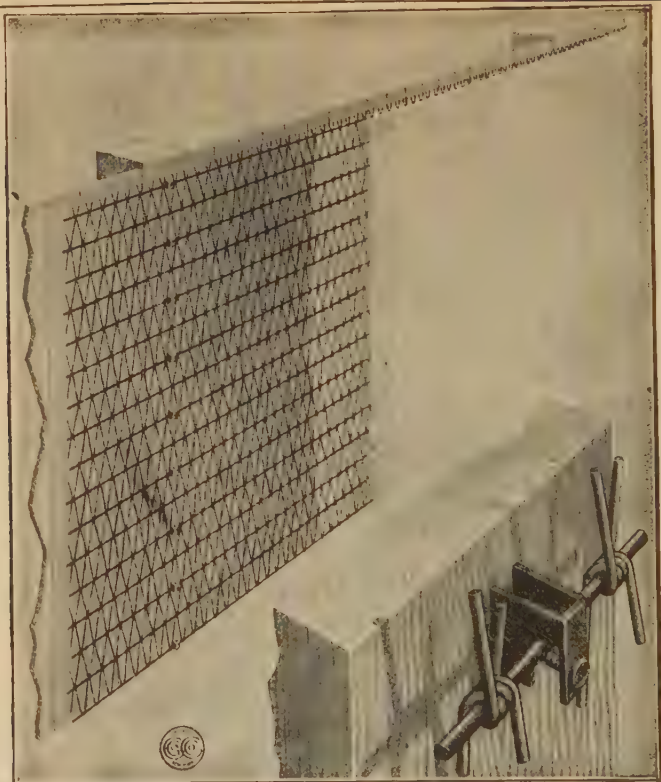


FIG. 5,050.—Columbian system showing method of placing the special form of Columbia bars on slabs, girders, and columns. This is a flat concrete system with ribbed steel tension member. Rolled joists are used for beams, embedded in concrete, the double cross floor reinforcement being held in place by flat iron inverted stirrups placed over the top flanges of the joists.

insure the adhesion between the concrete and the reinforcement. The following briefly described systems are of the most well known.



FIGS. 5,051 and 5,052.—Method used by Cement Gun Co., for holding wire mesh in place and application of stucco with cement gun.

FIG. 5,053.—Reinforced concrete floor slabs with reinforced concrete beams. This is probably the most common floor construction. A method of construction followed when the beams, girders and columns of the structure are reinforced concrete. The slabs and the supporting beams are poured at the same time so as to make the structure monolithic and permit the design of the beams as T-beams.



FIG. 5,054.—American triangle mesh fabric floor reinforcement as laid.

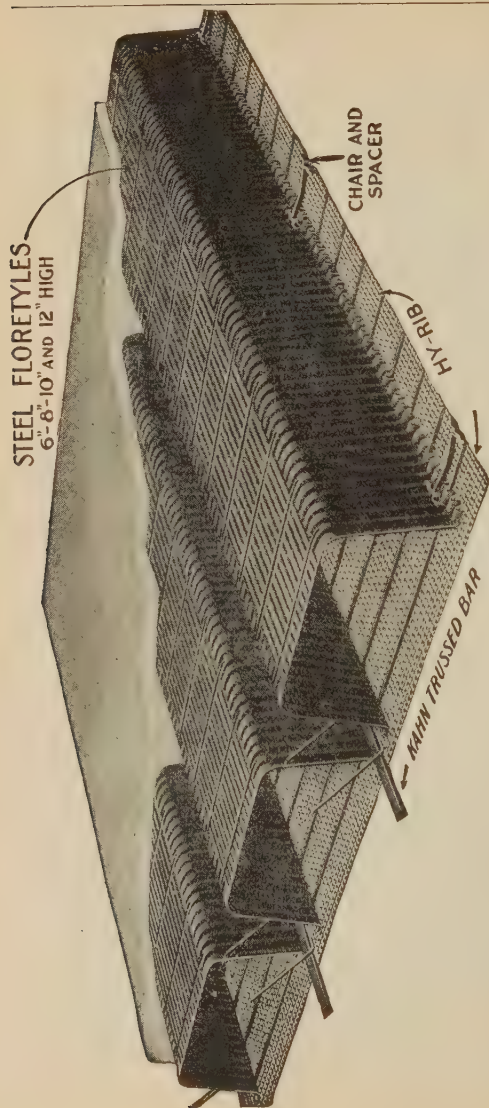


FIG. 5,055.—Truscon steel floretyles. This popular type of reinforced concrete construction consists of rows of specially manufactured hollow steel tile covered with a layer of concrete and separated by reinforced concrete joists. These deep, narrow joists carry the loads directly to the supports, while the floretyles act merely as fillers, saving concrete, reducing dead weight, simplifying centering and economizing construction.

NOTE.—Placing Hy-rib. The Hy-rib sheets are first laid on the centering, thoroughly interlocking them at sides and end and clamping the interlocking ribs with Hy-rib punch. The ribs of the hy-rib run at right angles to the joists of the Floretyle construction. Placing Floretyles. To lay a row of Floretyles place the first tile with the large or free end next to the support. The free end of the next Floretyle is then readily lapped over the ripped end of the first tile and the same operation continued throughout the length of the row. Floretyles can be rigidly tacked to the wood forms by nailing through the flanges along the bottom edge. A nail at each end and center on both sides (four nails in all) should be sufficient for each Floretyle. These nails should be tacked tightly so that they enter the wood not over $\frac{1}{4}$ in. in order not to interfere in any way with

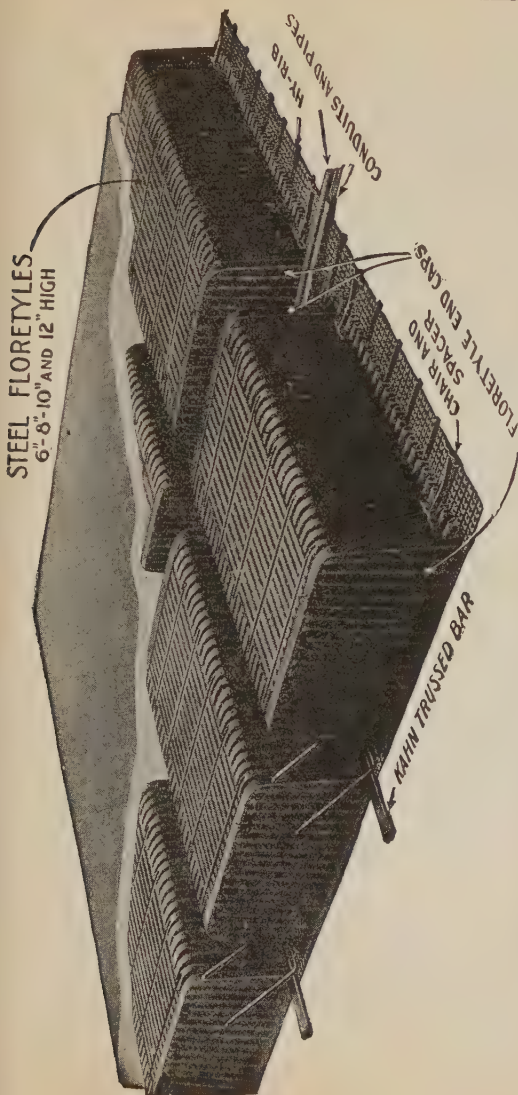


FIG. 5,056.—Truscon "Floretyle" end caps used to close ends of standard "Floretyle." These caps are smaller at the base than Floretyles, but are readily placed by sliding them over the ends from above.

Continued from opposite page.

the plastering after removal of forms. The Floretyles at each end of the rows should not be tacked down until the end caps are set in place. The rows of the Floretyle are accurately spaced by means of the spacer chairs which are the exact width of the joist. These spacer chairs also serve the purpose of holding the reinforcement the correct distance above the hy-rib. Placing end caps. The end cap is placed by sliding it over the end of the Floretyle from above. The lugs near the top of the end caps fit under the free ends of the Floretyles, furnishing a support for the end and permitting a nail to be driven through the cap and edge of the Floretyle. The end caps are merely fitted over the ribbed ends of Floretyles. In all cases the two corner flanges at the base of the end caps should be lightly tacked to the wood forms. End caps can also be used at any place in the span where conduits or pipes extend across the joists.

System M.—This type of construction, as shown in figs. 5.062 and 5.063, consists of a light steel frame designed to carry the dead load of the entire structure, except that the columns are designed to carry the gross loads. The

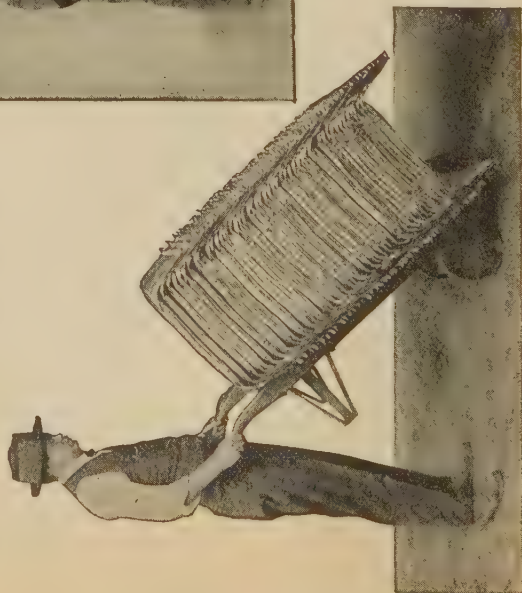


FIG. 5.058.—**Handling Floretyles.** 2. A stack of 50 Floretyles on a two-wheeled truck is equivalent in floor construction to 333 terra-cotta tiles weighing over 10,000 lbs.



FIG. 5.057.—**Handling Floretyles.** 1. Insert separator with flat side up below corner of top Floretyle and push through bundle.

structure is incased in concrete, making ultimately a reinforced-concrete construction. Its advantage consists

in being equivalent in floor construction

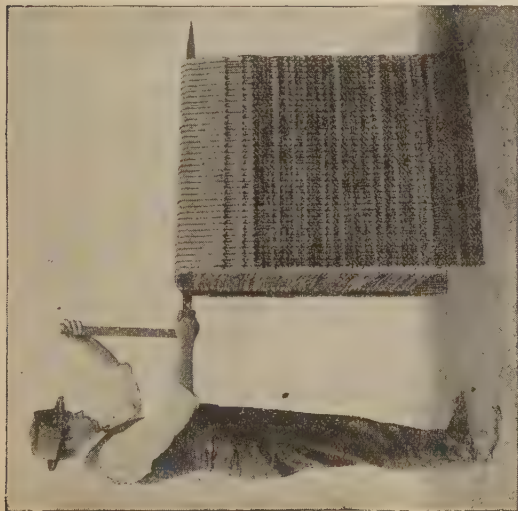


FIG. 5,059.—*Handling Floretypes. 3. Turn separator on edge to loosen Floretype.*



FIG. 5,060.—*Handling Floretype. 4. Use separator as lever to remove Floretype.*

its adaptation to the erection and inspection of the steel reinforcement before even the centers or moulds are placed in position. Under congested conditions, such as prevail in large cities, it is a rapid form of construction. The use of the steel in this type is however, not economical. In order to get the necessary strength in the steel

framework, shapes must be used which do not offer the amount of adhesion that should result from the amount of metal used. Furthermore, such shapes must necessarily be subjected to some bending, which tends to break the bond between concrete and steel.

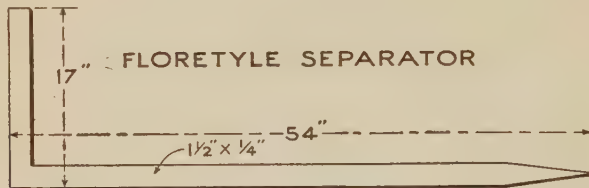
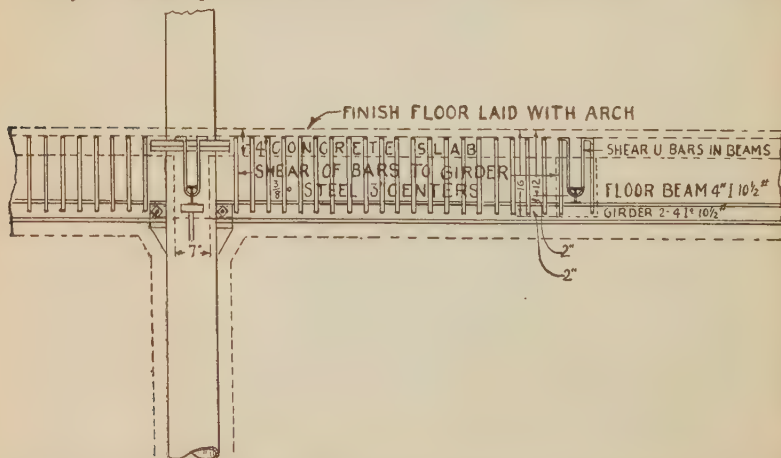


FIG. 5,061.—Florestyle Separator. A Florestyle separator is included in the first shipment of Florestyles. Insert separator, with flat side up, below corner of top sheet and push through bundle. Then turn separator on edge to loosen Florestyle and use it as a lever to remove the tyle from the top of the stack.



FIGS. 5,062 and 5,063.—System M. Form of reinforced girder and beam construction. This system consists of an independent light steel frame, which is subsequently so united to concrete that the two become a reinforced construction. The upright iron or steel supports and the steel floor members can be formed with sections of any shape suitable to make a light independent structure capable of maintaining its form. The steel uprights are erected plumb and the steel floor members are set level. The girders are connected to the uprights to keep them plumb, and the floor beams are connected to the girders to make a sufficiently rigid structure.

Skeleton System.—In this system a framework of columns, girders, beams and flooring is built, as in steel construction, the wall girders and columns, of course, being designed to carry the weights of the outside walls as well as that part of the floor loads and live loads which comes on them. The work, in this type of construction, can generally progress more steadily than in the mill construction, since the concrete work need

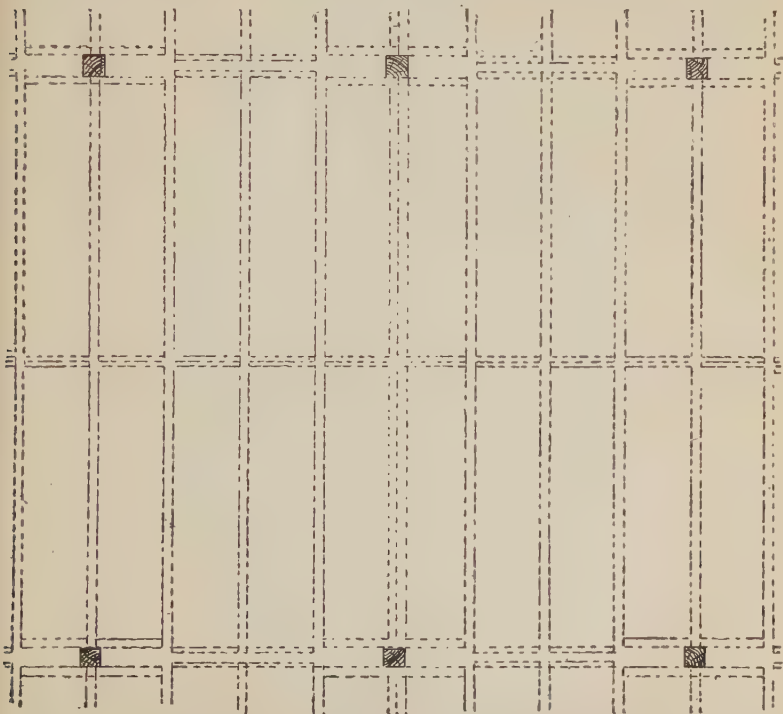


FIG. 5,064.—Ransome system. *It consists of* reinforcing concrete floors and beams by the use of rods. This system consists of reinforced beams, quite thin and deep, with web stiffeners spaced about like floor joists in ordinary construction work, and supported by girders at the ends. Several bars are grouped in parallel layers for the heavier girder reinforcements. In the case of long spans in the beams a central stiffening web is often used as bridging between the beams.

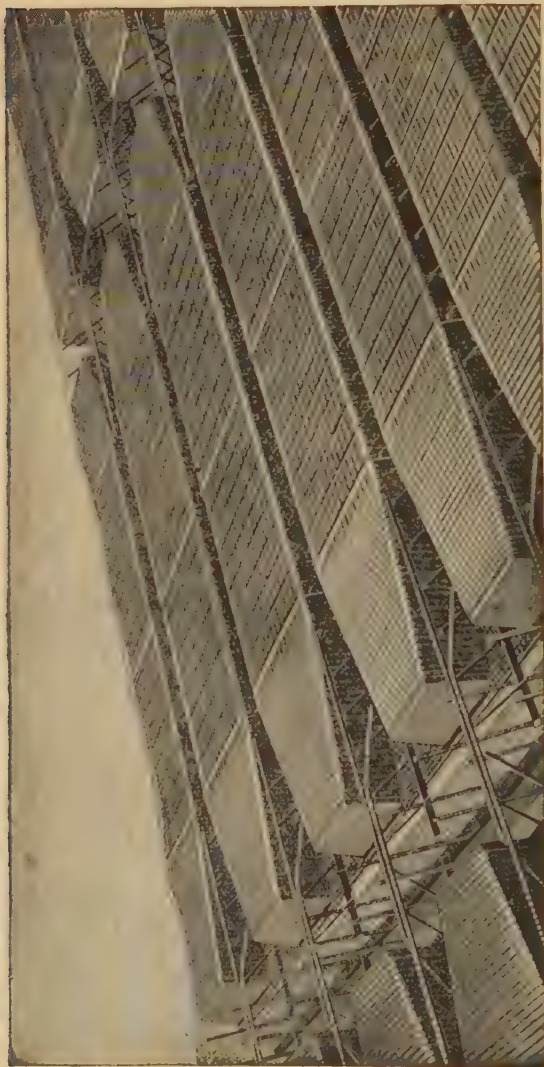


FIG. 5,065.—Trucson cantilever floor construction. The cantilever designs are notably strong and rigid, and exceptionally economical of materials. The use of cantilevers in reinforced solid concrete construction necessitates arched ceilings, which often present decided disadvantages. Cantilever Floretype construction provides flat ceilings of long span, every point in the span assuring maximum economy.

NOTE.—*Properties of cantilever Floretypes.* Standard heights 6, 8, 10 and 12 inches. 12" cantilever Floretypes are not carried in stock, but are furnished on special order, if sufficient time be allowed. Approximate width at wide end $20\frac{1}{2}$ in.—at narrow end 13 $\frac{3}{4}$ in. Lengths (nominal) 2 ft., 3 ft., and 4 ft. Actual lengths are 1 in. greater to allow for end laps. Cantilever end types are placed under the free end and over the ribbed end of Floretypes, both lefts and rights being exactly the same. Small end of Cantilever Floretype is closed by special Cantilever end caps, as shown in above illustration. These end caps are placed by sliding over the ends from above and are tacked to the forms at the corners the same as Standard end caps.

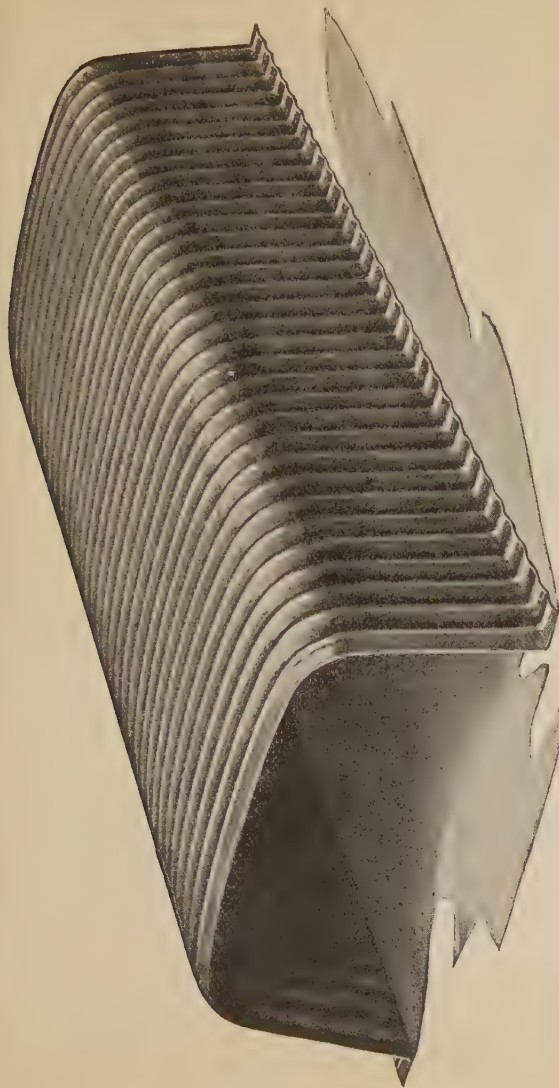
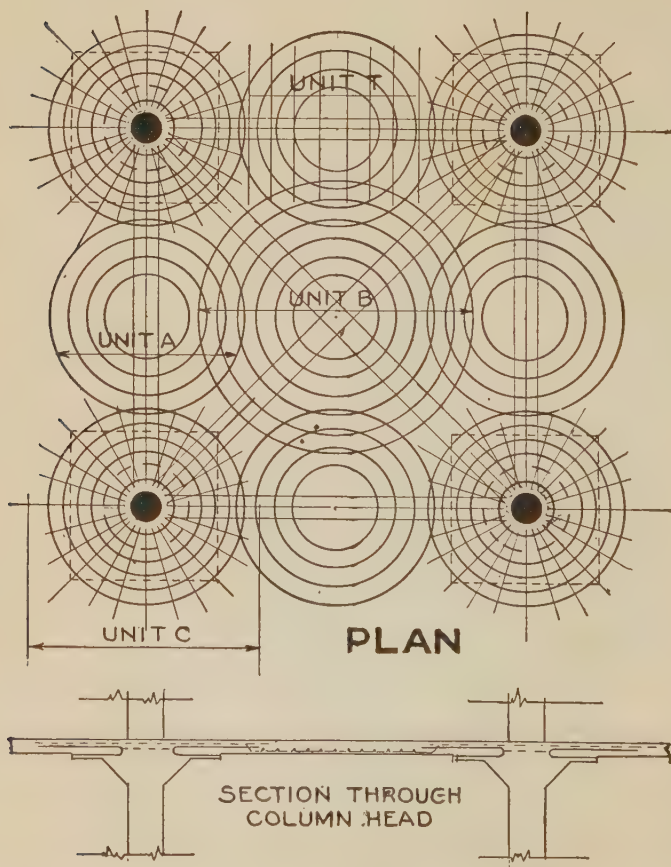
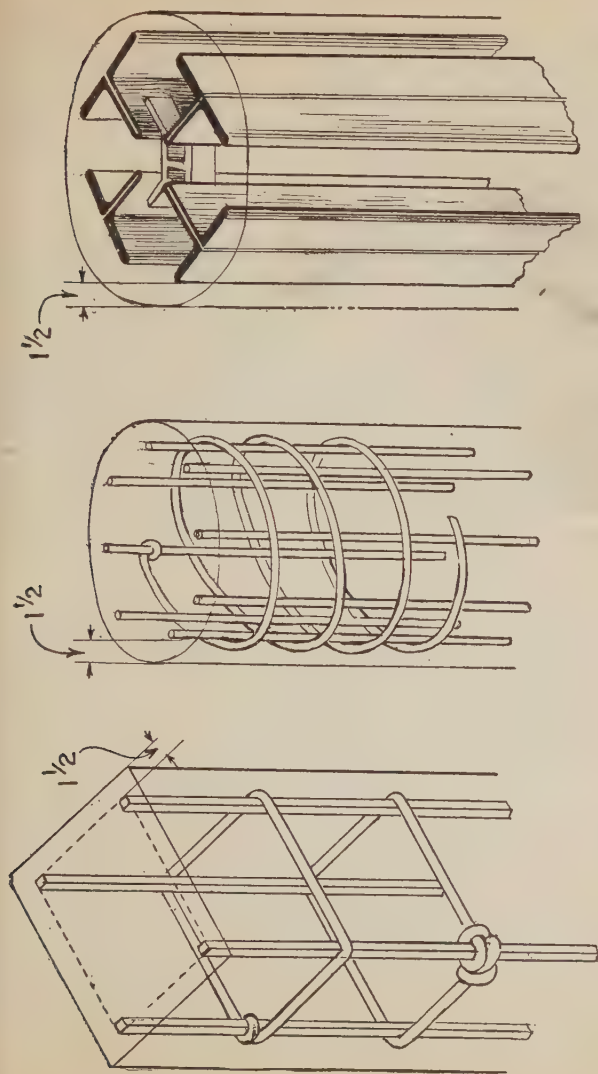


FIG. 5,066.—The corrugated tiles differ from the ribbed in that they are furnished in shorter lengths and lack the deep stiffening ribs across the tops. The profile has been so designed that the concrete quantities for both the corrugated and ribbed tiles will be identical. Floretiles are made with one end $\frac{3}{4}$ in. wider than the other, so that they can be easily lapped. End caps, manufactured under special dies, are used to close the ends of Floretiles.

not be stopped at any time to wait for the brickwork to be carried up, if brick be used for the walls. In the skeleton construction any type of outside wall may be used; brick, concrete, tile, etc. In some cases the panels are simply filled in with brickwork, 8 or 12 in. thick, leaving the concrete columns and girders showing between the brick panels.



FIGS. 5,067 and 5,068.—S. M. I. flat slab system. *In the system* circumferential and radial reinforcement is placed in both the top and bottom of the slab, with trussed bars extending both rectangularly and diagonally between the columns. The radial bars are provided with a semi-circular hook to transfer the stresses into the concrete by hand and to engage the ring of reinforcement in the center of the panel. To prevent cracking on the top of the slab between columns additional short straight bars are sometimes used.



FIGS. 5,069 TO 5,071.—Three types of column reinforcement. Fig. 5,069, longitudinal rods with spiral ties; fig. 5,070, longitudinal rods with rectangular ties; fig. 5,071, structural shape reinforcement.

Flat Slab System.—In this construction the slab is made to rest directly on the columns, thus eliminating beams and girders. The tops of the columns are enlarged into extended caps.

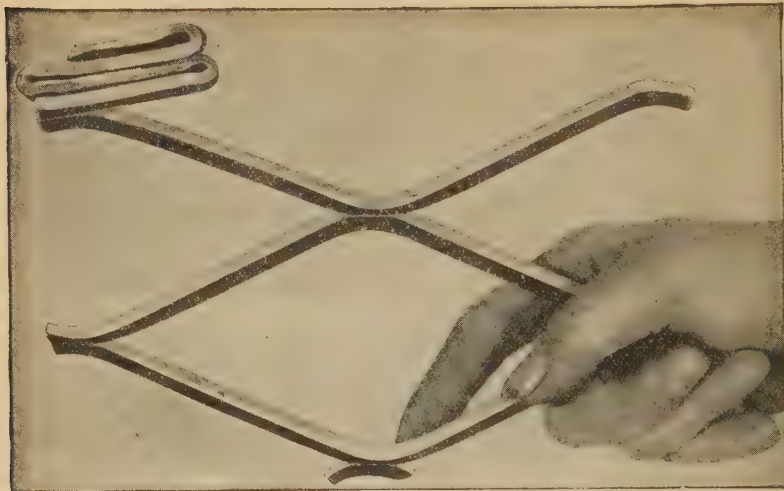


FIG. 5,072.—Cold binding test. *It consists of* sharply bending a bar or portion of a structural shape and noting the angle at which rupture occurs on the convex section of the bend. If the material can be bent through an angle of 180° without rupture, it is considered to have exhibited a high degree of ductility.



FIG. 5,073.—Another test to determine the strength and ductility of steel used in the manufacture of *Econo*.

Based on the method of reinforcing the slab and columns a number of systems have been developed which may be divided into four general classes:

1. Two way system.
2. Three way system.
3. Four way system.

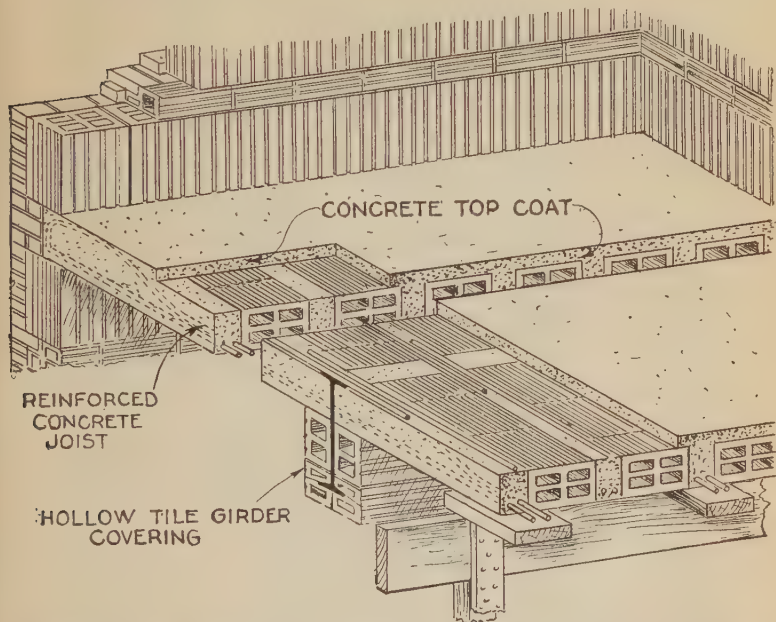


FIG. 5,074.—One way tile joist slab. *In erection*, the tiles are placed about 4 or 5 ins. apart, the concrete in the channels between the rows of tile serving as joists and carrying the reinforcement.

Two Way System —The reinforcement is placed in direct bands between the columns in both directions, with an interior system of two way rectangular bands on the remaining panel area at the center.

Three Way System —The reinforcement is placed in bands directly connecting the columns and passing over the column heads.

Four Way System —The reinforcement is placed in two direct bands in the two rectangular directions and in two diagonal bands which cross the

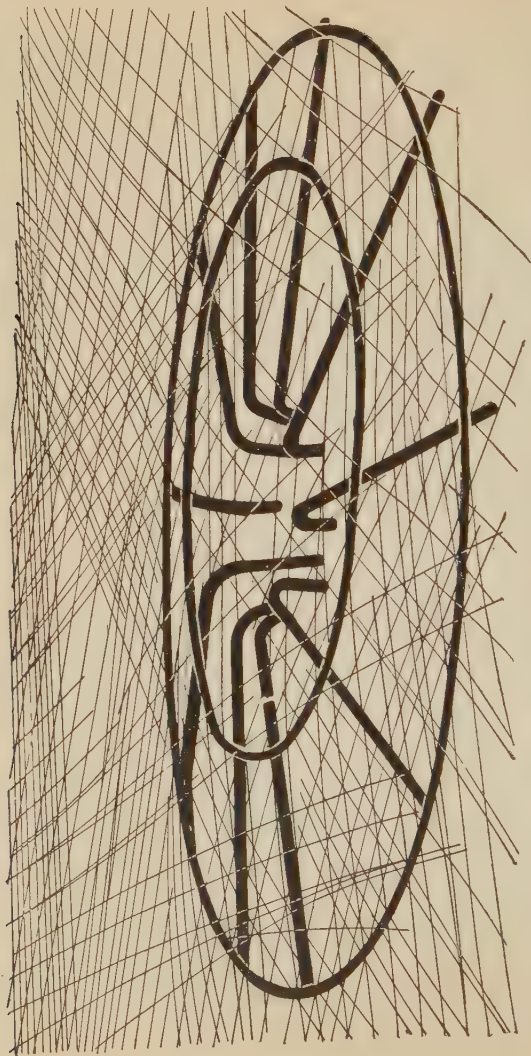


FIG. 5.075 —Mushroom system, so-called from the peculiar formation of the rods around the column head and from the remarkable rapidity with which it may be erected. The arrangement of the reinforcement is designed with a view to securing the maximum efficiency of the materials through straining the concrete in a number of directions, the compression in one direction tending to balance and offset that in another; incidentally to concentrate the maximum amount of reinforcement around and over the support where the shear is the greatest; to enable removal of the forms at the earliest possible period; and finally to eliminate beams and ribs which interfere with light and catch dust, cost money to plaster and finish, and reduce the clear story height.

Mushroom System.—This is one of the earliest flat slab construction. The feature of this system is the gradual spreading out of the column at the top (like a mushroom, hence the name) to form a cap, the diameter of which is $\frac{7}{16}$ of the sum of the distance between columns in the direction of the sides of the slab. The longitudinal column reinforcement is bent to follow the curved outer surface of the cap and the cap is

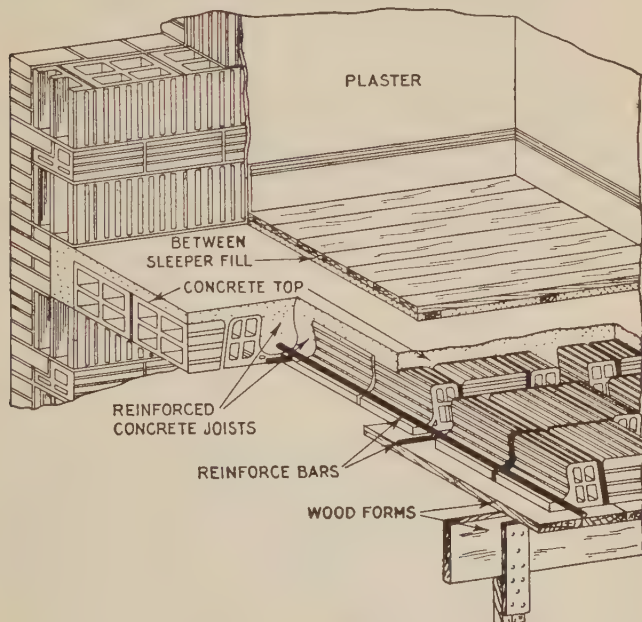


FIG. 5,076.—Two way tile joist slab. This construction combines the advantages of light dead weight and thinner slab.

reinforced both radially and circumferentially. The slab reinforcement is placed at the top of the slab over the columns and allowed to sag to a catenary curve with the low point near the bottom of the slab at the middle of the span. This

is essentially a four way system with the added features described above.

Combination Hollow Tile and Reinforced Concrete.—This construction seeks to minimize the cost of centering. As shown in fig. 5,077 it consists of a series of reinforced concrete beams with clear spaces between them of the width of the

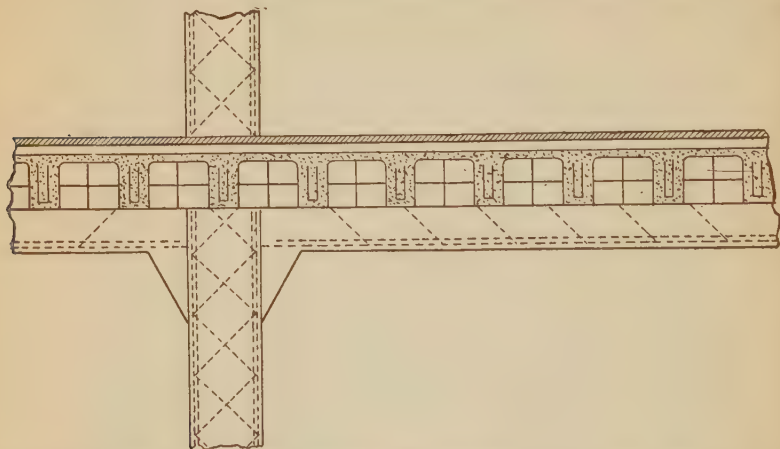


FIG. 5,077.—Combination tile and reinforced concrete system. *In erection*, a flat centering is used which, however, need not even be continuous. Planks a few inches wider than the concrete beams are placed under the spaces to be filled by the beams and the tiles are laid in rows and supported along their edges by the planks, thus forming the sides of the moulds for the beams. The reinforcement is placed and the concrete poured with or without floor plates, as the necessities of the case may require. Care must be taken in pouring the concrete that the tiles are not displaced sidewise. The tiles should fit closely at their joints, otherwise the finer particles of the concrete are liable to flow into them, either making the concrete porous or requiring more concrete than is necessary.

hollow tile blocks. This form of construction, besides being economical in centering, offers the advantages of a flat ceiling without the application of lath and in roof construction particularly of freedom from condensation.

Bending Reinforcements.—Careful attention should be

given to methods of bending, not because of any difficulties presented, but on account of the large number of bends that must be made on work of any size. It is accordingly desirable for economy to make the bends in the most efficient manner. Bending should be done in such a manner that the bars will not break or crack at the bend.

There are in general five different types of bends:

1. Bending heavy beam and girder rods.

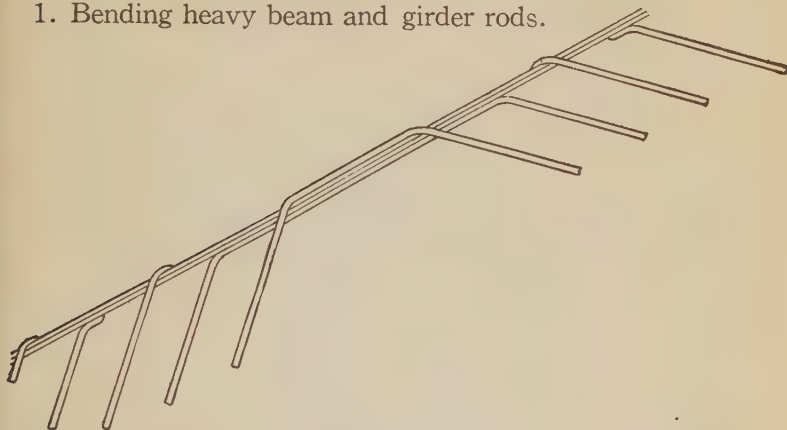


FIG. 5,078.—Kahn trussed bar as used in the Kahn system. *This system* consists of what may be considered as a large number of separate members all rigidly attached and handled as a unit. The labor saving in handling a single piece as compared with many separate individual parts is one of the advantages claimed for this system. The bar has two horizontal flanges or wings projecting at diametrically opposite corners. These winged portions are turned up at intervals and bent so as to make an angle of 45 degrees with the main portion of the bar. It is claimed that in this bar there is no waste metal at any point and proper reinforcement is provided at every place it is needed. For instance, in the central portion of the beam where the full section of metal is needed for bending moment, and no reinforcement required for shear, the bar is unsheared and the full area of the metal is available. At the ends of the beam where the shear is a maximum and the bending moment a minimum, the flanges of the bar are struck up to form rigidly attached shear members which carry the shearing stresses directly to the main tension member.

2. Bending vertical reinforcing rods of columns at or near floor level where columns change size.
3. Bending stirrups and column hoops.
4. Bending slab reinforcement.

5. Bending rods or wire in form of coils for spiral column reinforcement.

In bending, the work should always be so arranged that all rods of the same size and shape are bent at the same time. Various types of bending devices have been produced.

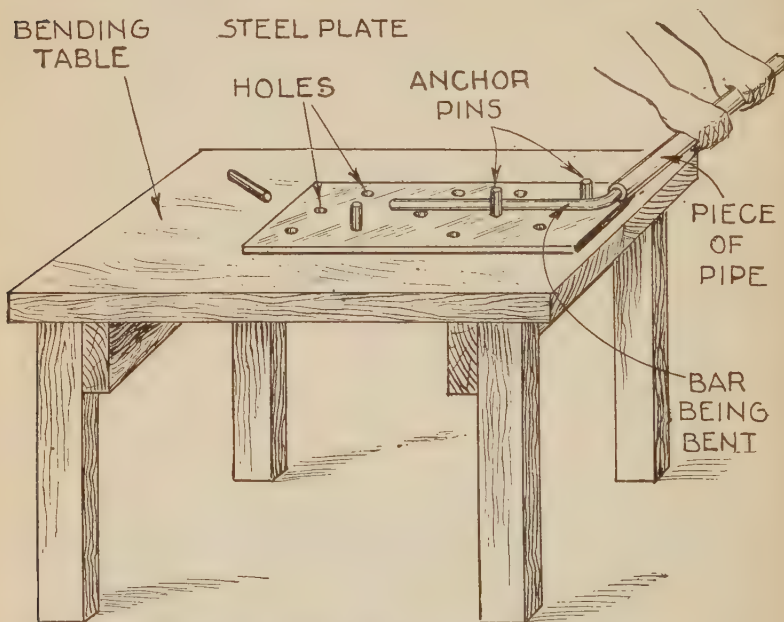


FIG. 5,079.—Bar bending table showing method of anchoring bar on plate with anchor pins and method of bending bar with piece of pipe telescoped over bar to be bent.

The bending of bars is often done by hand on the job. A simple method of bending by anchoring the work on a table and using a piece of pipe is illustrated in fig. 5,079. Numerous types of bending devices are shown in the accompanying illustrations.

Anchoring Reinforcements.—The reinforcing bars or rods should be secured at the ends so that the metal will take the

tensile stress without moving in the direction of the stress. The reinforcements are secured at the ends in various ways, as by

1. Washers and nuts.
2. Right bend.
3. Hook, etc.

Fig. 5,080 shows the washer and nut method; this, it should be noted, is an expensive but effective way to secure the ends.

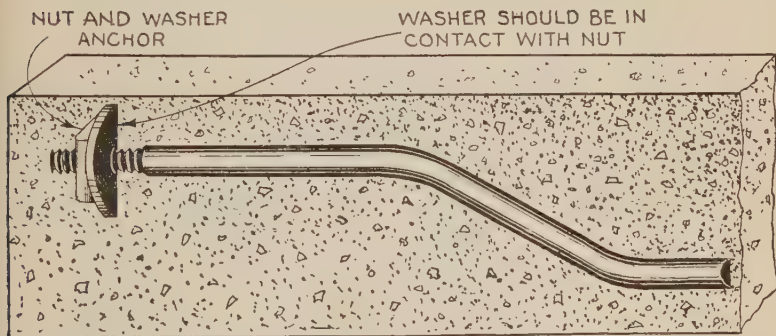
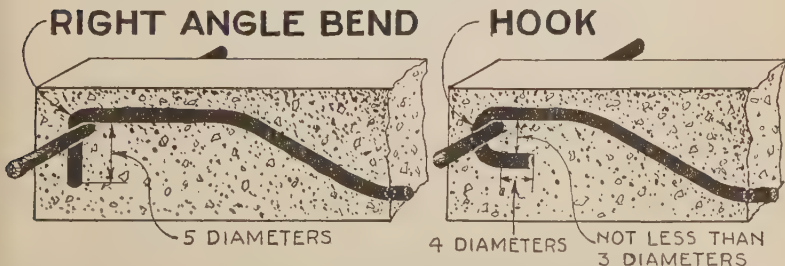


FIG. 5,080.—Nut and washer anchor. An expensive but effective method of anchorage when care is taken to keep the washers in contact with the nut in pouring.

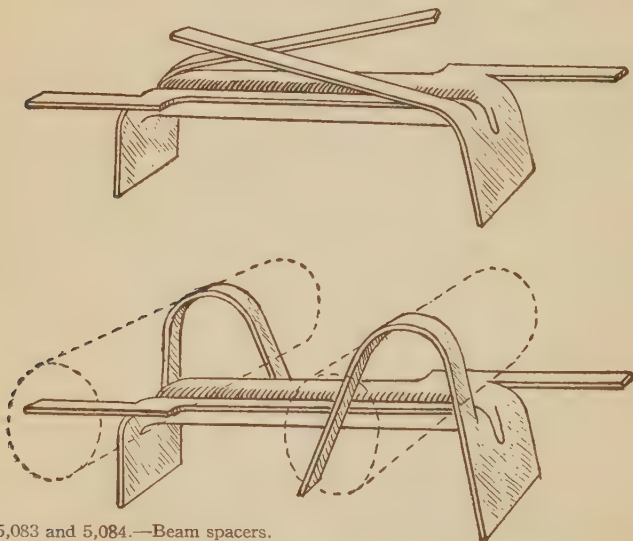


FIGS. 5,081 and 5,082.—Bent rod anchors. Fig. 5,081, right angle bend; fig. 5,082 hook bend. There is less danger of pulling out with the hook than with the right angle bend.

However, unless the washer be taut against the nut, the anchorage only acts after the bar has begun to slip.

When bars are brought to a stop in the end of beams, or other places that require rigidity, the common practice is to bend the bar into a semi-circular hook, with a radius of two times the diameter of the bar for the bend, and with a short length of bar beyond the bend as shown in fig. 5,082. The hook form, shown in fig. 5,081, is a less desirable method.

Supporting and Spacing Devices.—There is a multiplicity of devices for holding the reinforcements in position during



FIGS. 5,083 and 5,084.—Beam spacers.

the pouring of the concrete. Some are to support and others to space the reinforcements and yet others both support and hold the rods or bars at the proper distance apart.

Figs. 5,083 and 4,084 show beam spacers which space the bars accurately both from the sides of form and center to center of bars. Various forms of

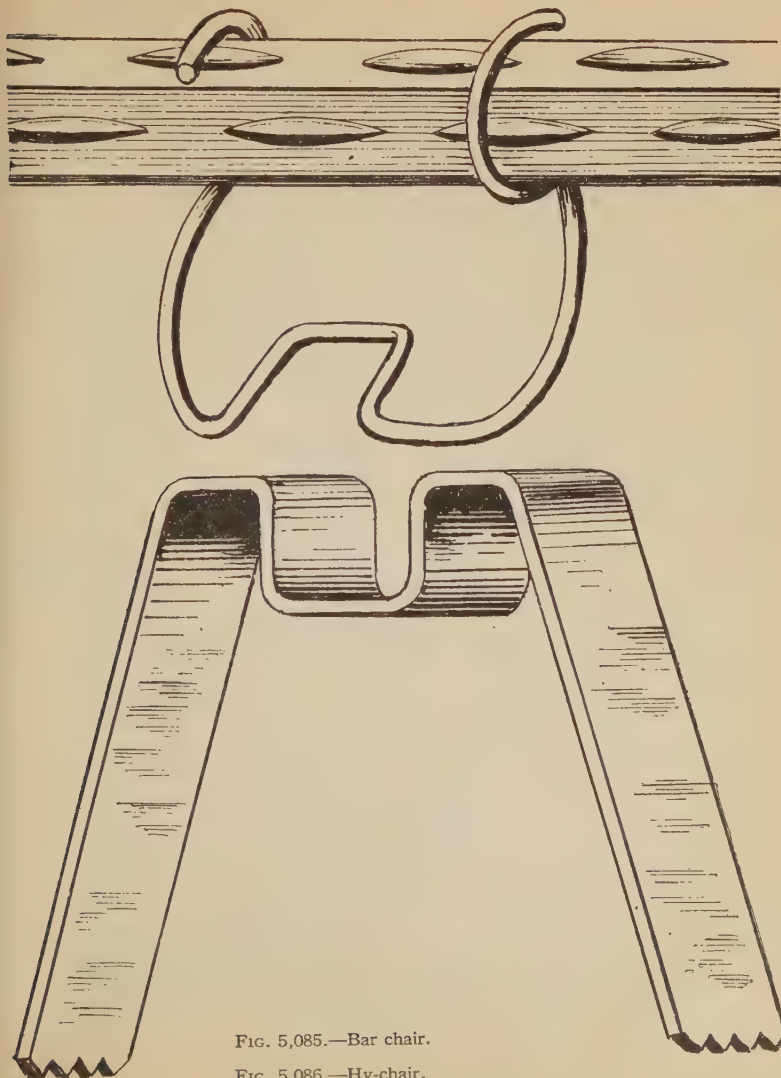


FIG. 5,085.—Bar chair.

FIG. 5,086.—Hy-chair.

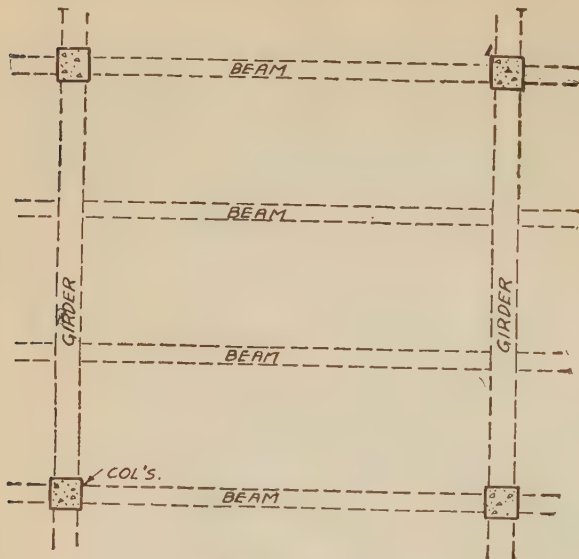


FIG. 5,087.—Am. S. & W. typical panel showing location of beams and girders.

FIG. 5,088.—Concrete beam section showing slab reinforcement.

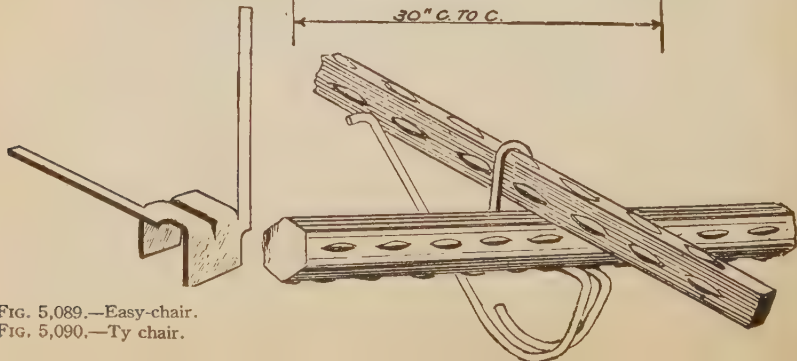
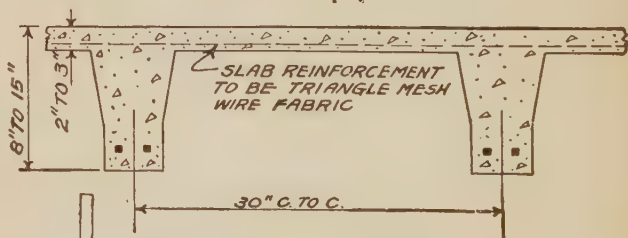
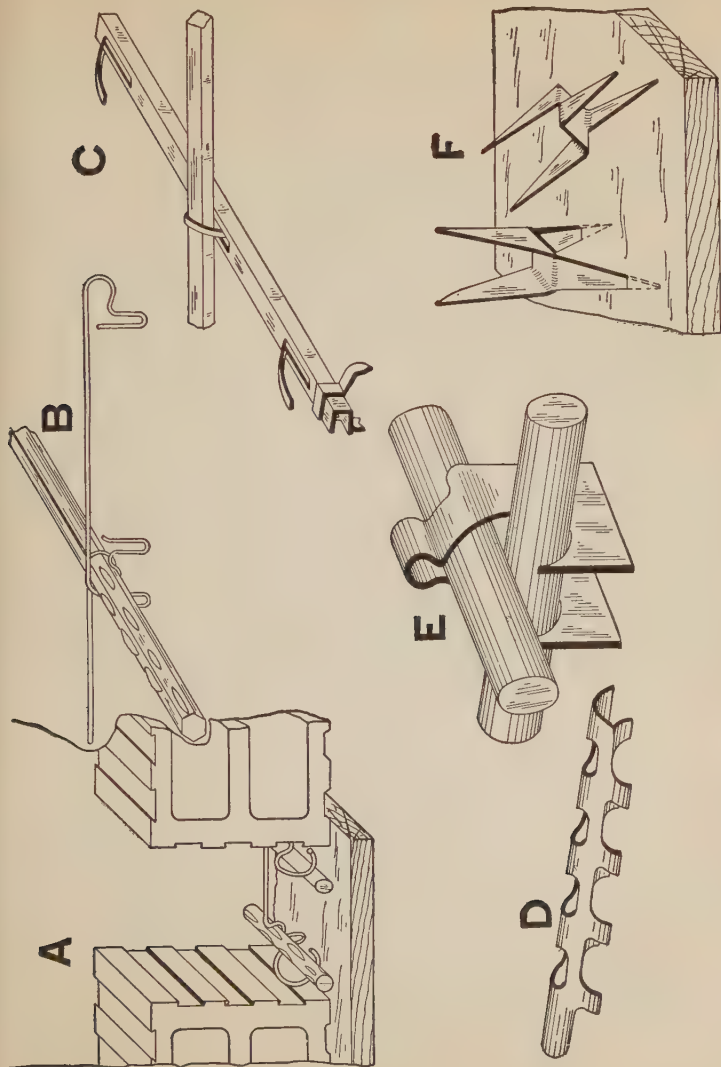


FIG. 5,089.—Easy-chair.

FIG. 5,090.—Ty chair.



FIGS. 5,091 to 5,096.—Various reinforcement accessories. **A**, application of easel chair showing rods spaced and supported; **B**, chair spacer; **C**, continued slab spacer; **D**, adjustable beam saddle; **E**, chain lock; **F**, staple chairs.

"chairs" support the reinforcement at the proper distance from the form. Some of these chairs perform the functions of both supporting and spacing. Numerous chair types are shown in the accompanying cuts.

Placing the Reinforcement.—While a slight film of rust is not objectionable, the steel should be thoroughly cleaned of loose rust scale with wire brushes and other foreign matter before being placed in position so as to secure the maximum adhesion between the steel and the concrete. The reinforcements should be carefully supported and spaced by means of the supporting and spacing devices just described so that when the concrete is poured they will not be displaced from their correct positions.

Particular attention should be given to nut and washer anchors to see if the washers be in contact with the nuts. Slab and wall rods should be tied with wire at their intersections to prevent them from slipping or getting out of place.

Special tying devices are used to quickly and securely tie the rods. Any loose bars which must be placed should be watched carefully during the pouring. The reinforcements should be tied by wire at all intersections; this is done with light wire and the tying device just mentioned.

CHAPTER 91

Stucco

In modern building construction stucco may be defined as *a mixture of cement, sand, hydrated lime and a sufficient amount of water to produce a workable mix.*

Sometimes the hydrated lime is omitted, but its presence helps to make the mixture "fatter," and in that respect easier to apply, also waterproofs it. While stucco does not make a building fireproof, it gives a large measure of fire protection to a structure that is constructed of combustible materials. It also preserves such buildings against rapid depreciation and naturally eliminates the necessity for frequent maintenance such as painting and the many common repairs that would be necessary without it.

Stucco is a better insulator than wood, hence a stucco building is warmer in winter and cooler in summer than a wooden building, also drier. Stucco can be applied so as to present a variety of surface finishes.

The recommended practice for using stucco has received much attention on the part of a committee of the American Concrete Institute which has long studied the deficiencies of stucco work as ordinarily practiced and has written recommendations for its use with a view of insuring the greatest measure of success and satisfaction.

Application of Stucco.—This building material may be applied in a number of ways, both to old and to new buildings. On old buildings it may be applied over:

1. Wood.
2. Brick.
3. Concrete.
4. Masonry.
5. Tile.

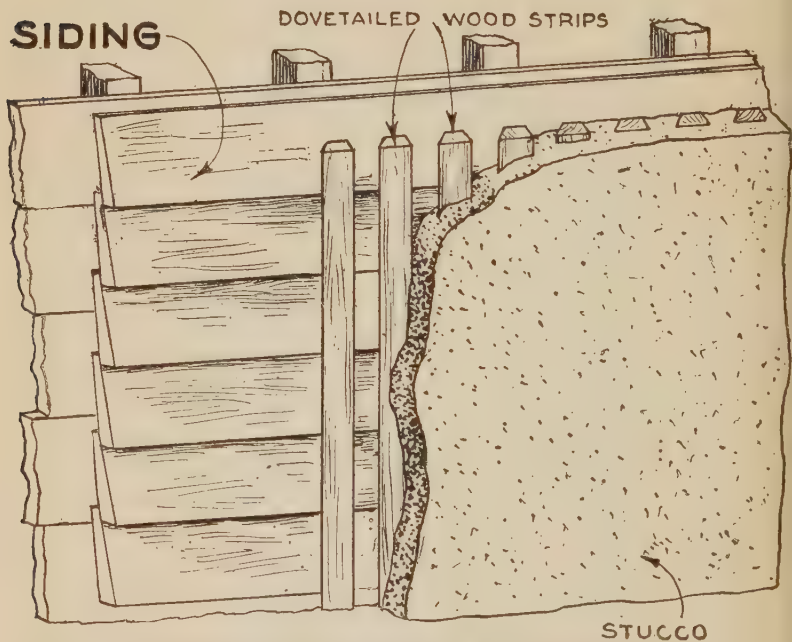


FIG. 5,097.—Stucco applied to old frame building. 1, as placed over siding.

And on new construction it may be applied over

1. Wooden lath.
2. Metal lath.
3. Wire fabric.

Old Frame Buildings.—The application of stucco to old

buildings does not require any great preparation. Unless the siding be in good condition, that is without being badly weather worn and sprung, it is better to remove same and apply stucco over sheathing rather than try to put the siding in condition.

Figs. 5,097 and 5,098 show method of applying stucco on old buildings respectively over siding and over sheathing. Various other details in the application of stucco to old frame buildings are shown in figs. 5,099 to 5,110.

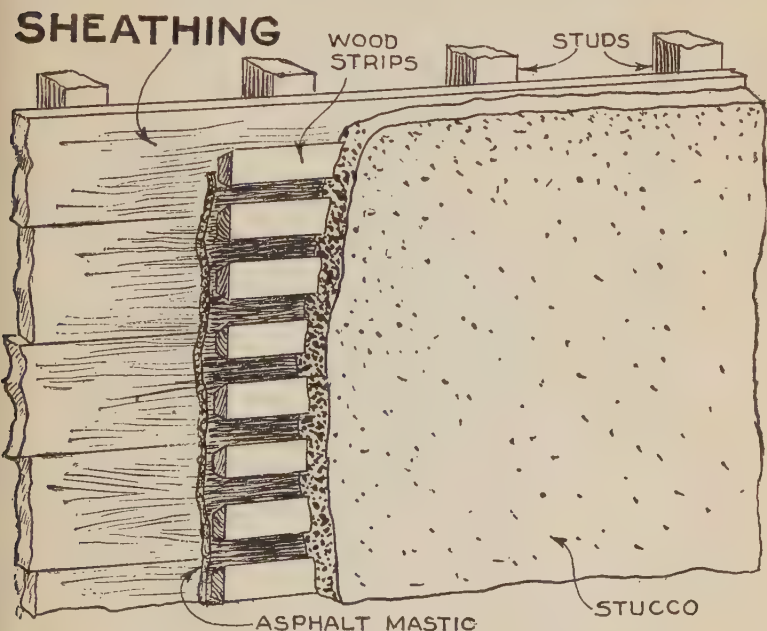


FIG. 5,098.—Stucco applied to old frame building. 2, as placed over sheathing.

New Frame Buildings.—Stucco for walls in new framed construction is extensively used. It cannot be too strongly emphasized that a rigid frame is necessary for satisfactory results. The adoption of any particular method of stucco

house construction depends largely upon the general class of the building to be enclosed, the cost, and degree of insulation against the weather desired. Thus, the stucco covering construction may be applied

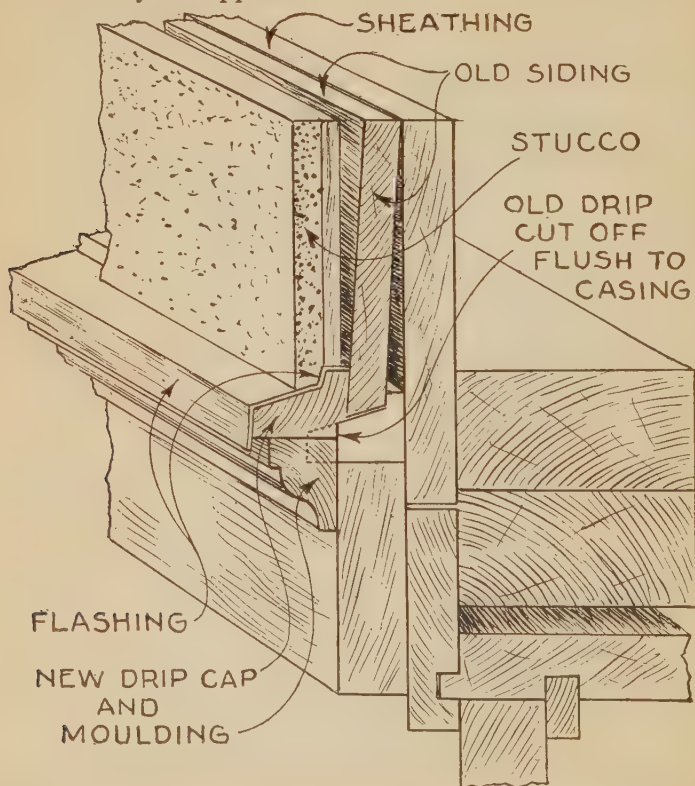


FIG. 5,099.—Stucco applied to old frame building, 3, treatment of window heads.

1. Directly to the studs.
2. Over Cabot's quilt.
3. Over two layer strips.

4. Over two layer strips and furring.
 5. Over horizontal sheathing.
 6. Over diagonal sheathing.
 7. Over diagonal sheathing and Cabot's quilt.
 8. Over metal lath or wire fabric.
- etc.

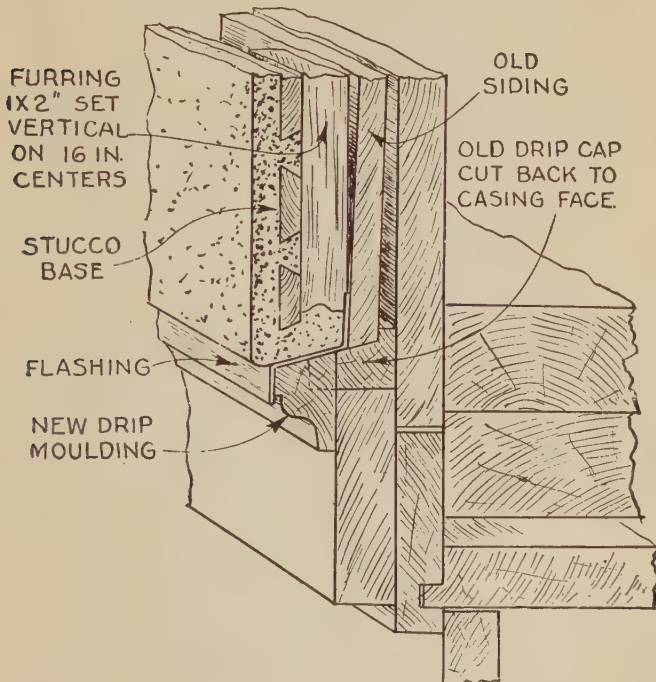


FIG. 5,100.—Stucco applied to old frame building (3 Continued). Treatment of window heads.

These various methods are shown in the accompanying illustrations.

Materials for Stucco.—Cement for stucco should meet the

requirements of the American Society of Testing Materials. Fine aggregate should consist of sand or screenings from crushed stone or crushed pebbles, free from dust, loam, vegetable and other foreign matter. It should be graded from fine to coarse and its largest particles should pass a No. 8 screen.

The water should be clean, free from acid, oil, alkali, and vegetable matter.

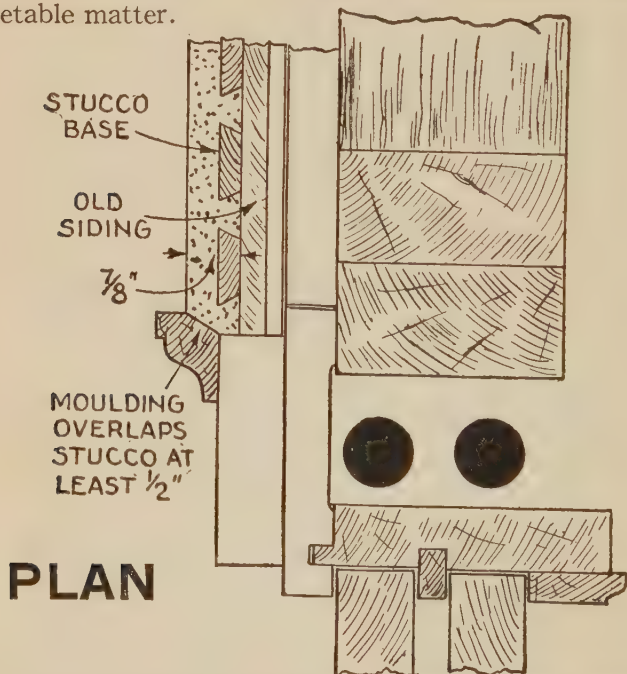


FIG. 5,101.—Stucco applied to old frame building. 4, treatment of window jambs

Hydrated lime should meet the requirements of the Standard Specifications for Hydrated Lime of the American Society for Testing Materials. When used it should be carefully measured and added to the sand and cement dry. The amount of

hydrated lime in no case should be more than one-fifth the volume of Portland cement.

Permanent mineral colors only should be used in stucco work. These colors should be fully guaranteed by their manufacturer

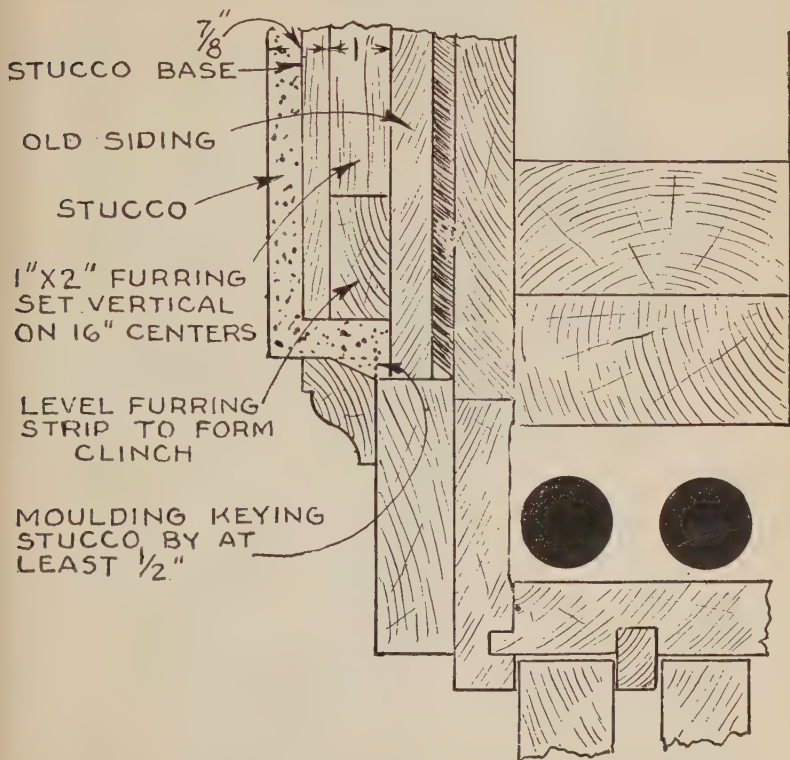
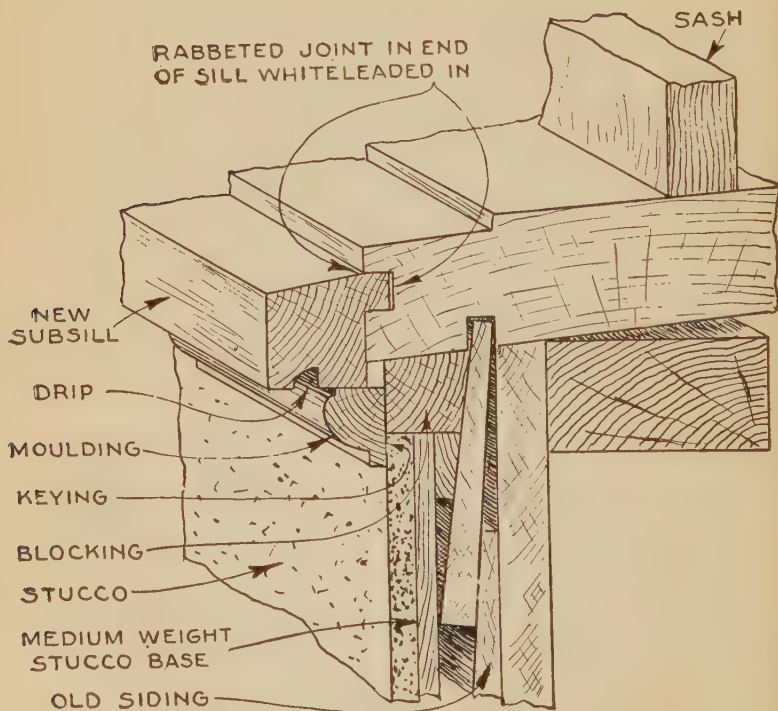


FIG. 5,102.—Stucco applied to old frame building (*4 continued*). Treatment of window jambs.

to be unaffected by lime, cement or weather. The amount of coloring used should not be more than 10 per cent of the weight of the Portland cement. The coloring matter and fine

aggregate should be mixed together first and then the cement added. The whole should then be mixed dry by shoveling from one pile to another through a one-quarter inch wire screen until the entire pile is uniform in color. Water should



FIGS. 5,103.—Stucco applied to old frame building. 5, treatment of sills.

then be added to bring the mortar to a proper plastering consistency.

The following table gives the colors to be used.

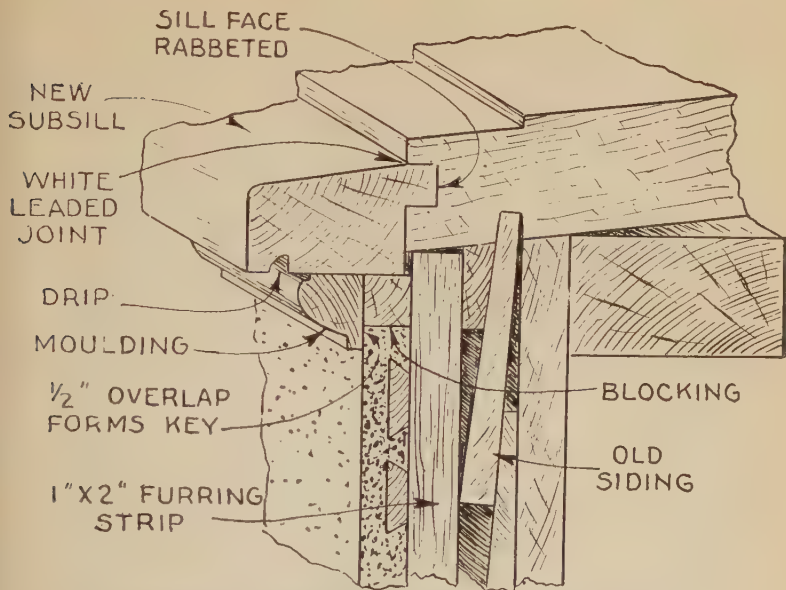


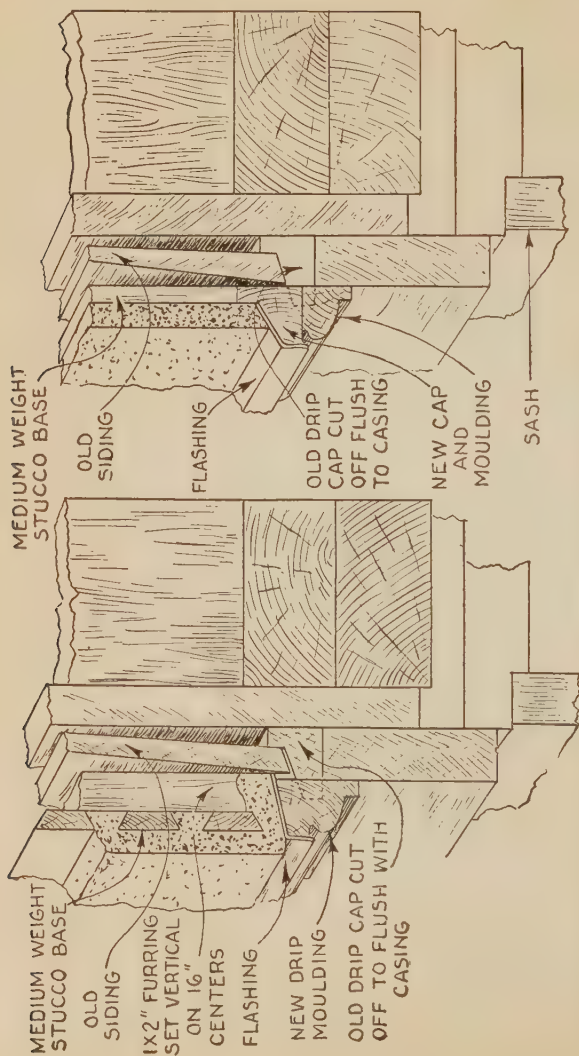
FIG.5,104.—Stucco applied to old building, 5 continued. Treatment of sills.

Table of Colors to Be Used in Portland Cement Stucco

COLOR DESIRED	COMMERCIAL NAMES OF COLORS FOR USE IN CEMENT	Pounds of Color Required for Each Bag of Cement to Secure	
		Light Shade	Medium Shade
Grays, blue-black and black.....	{ Germantown lampblack*.....	1/2	1
	{ Carbon black.....	1/2	1
	{ Black Oxide of manganese.....	1	2
Blue shade.....	Ultramarine blue.....	5	9
Brownish-red to dull brick red.....	Red oxide of iron.....	5	9
Bright red to vermilion.....	Mineral turkey red.....	5	9
Red sandstone to purplish-red.....	Indian Red.....	5	9
Brown to reddish-brown.....	Metallic brown (oxide).....	5	9
Buff, colonial tint and yellow.....	{ Yellow ochre**.....	5	9
	{ Yellow oxide.....		
Green shade.....	{ Chromium oxide.....	5	9
	{ Greenish blue ultramarine.....	6	~

*Only first quality lampblack should be used. Carbon black is light and requires very thorough mixing. Black oxide or mineral black is probably most advantageous for general use. For black use 11 pounds of oxide for each bag of cement.

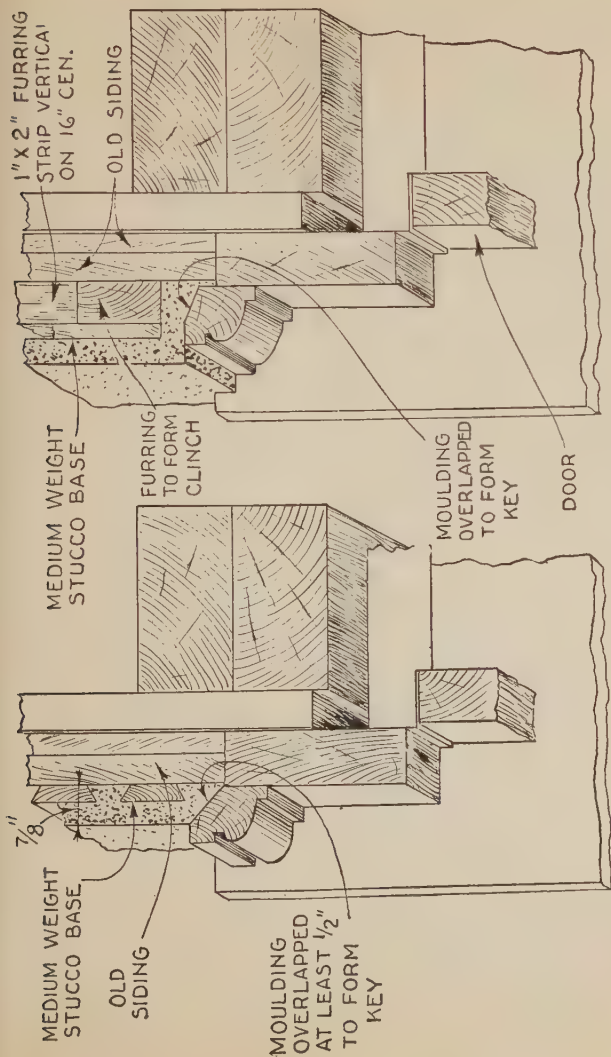
**Should contain not less than 15 per cent of the oxide.



FIGS. 5,105 and 5,106.—Stucco applied to old frame building. 6, treatment of door heads.

Hair or fibre should be used in the scratch coat only when stucco is applied over wire lath that is to be back plastered or on metal or wire lath applied over sheathing and is separated therefrom by furring deeper than $\frac{3}{8}$ -inch.

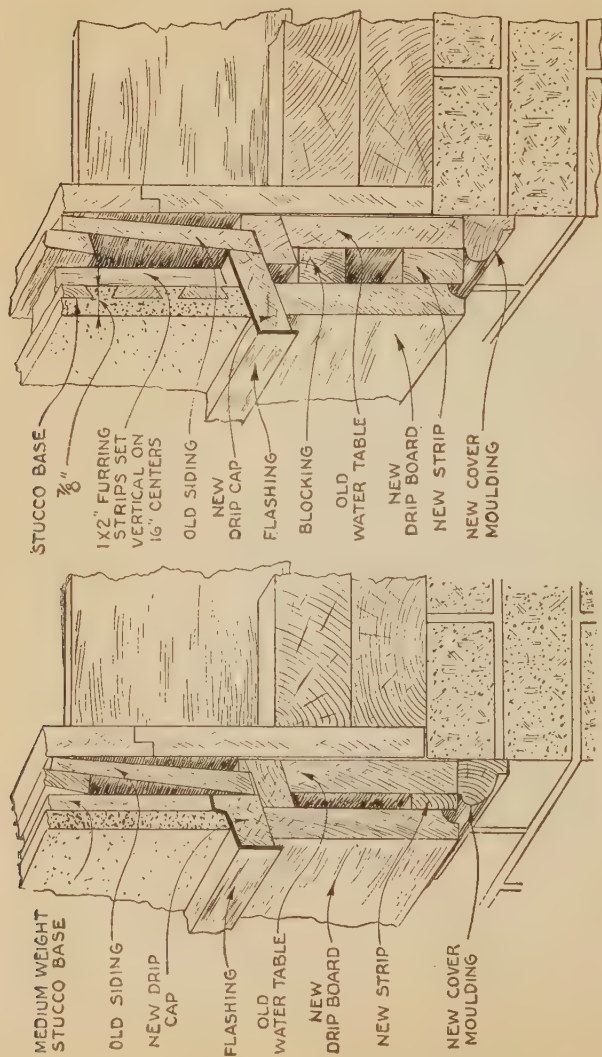
In applying the stucco, the surface must first be thoroughly scrubbed with brush and water. If it



FIGS. 5, 107 and 5, 108.—Stucco applied to old frame building. 7, treatment of door jambs.

had been painted previously, the paint should be removed before scrubbing. Immediately before applying stucco the surface should be saturated with water to prevent it absorbing moisture from the plaster.

Mortar joints should be picked back so as to provide a better bond between wall and plaster.



Figs. 5, 109 and 5, 110.—Stucco applied to old frame building. 8, treatment of water table.

Plastering should be started at the top of the wall and continued downward. The work should be done continuously. The materials should be measured carefully for every batch of plaster to insure uniform color.

If preferred, a brick or masonry surface may be furred and treated like a frame structure.

Number of Coats.—As a rule two coats of plaster are used in stucco work unless some particular final finish be desired, when a third coat is applied. The first, or scratch coat as it is called, is generally composed of two parts of clean well graded sand to one part of cement, with hydrated lime added in an

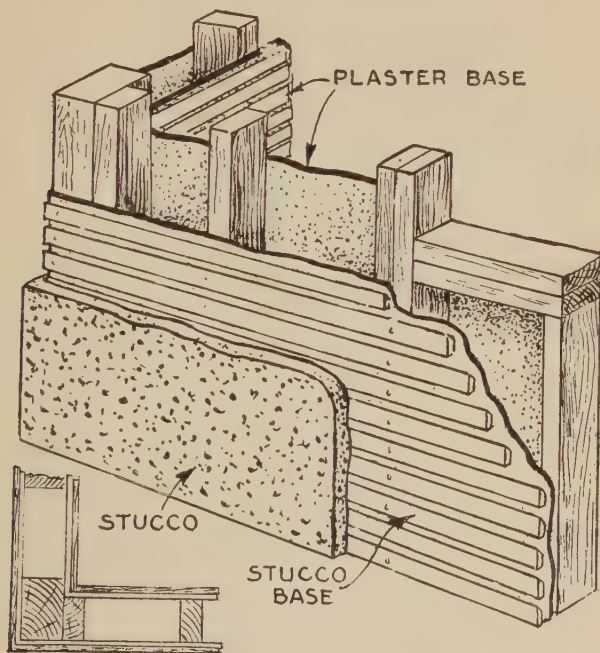


FIG. 5,111 and 5,112.—Stucco applied to new frame building. 1, directly to the studs.

amount equal to 10 per cent of the cement. Often a small quantity of cow hair is added to the mixture for the first coat to give greater bond or key with the lath. This coat should be from $\frac{3}{8}$ - to $\frac{1}{2}$ -inch thick and before it has become hard, it should be scratched, with some kind of a tool having saw

toothed edge so that the surface will be roughened to form a good bond for the next coat.

Mortar.—The mortar for all coats should be mixed in the proportion of one part by volume of Portland cement, to

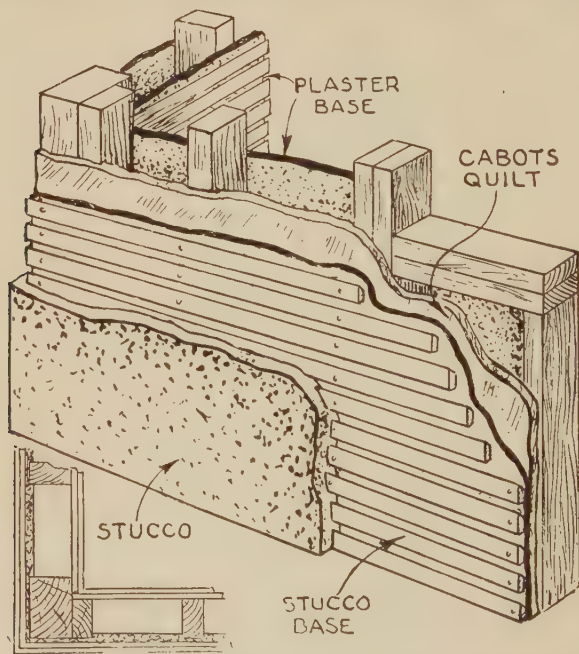
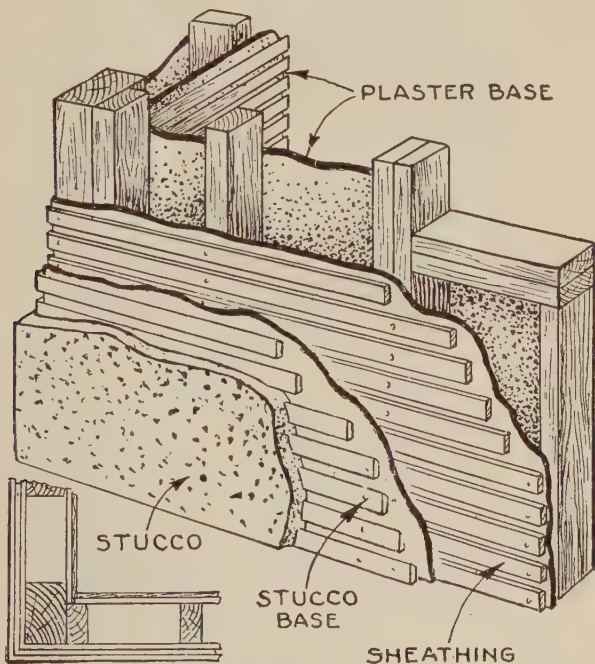


FIG. 5,113 and 5,114.—Stucco applied to new frame building. 2, to cabots quilt over studs.

three parts of the fine aggregate. A sack of Portland cement is considered as one cubic foot. The exact proportion of materials for the mortar including water, must be uniformly maintained throughout the entire job.

Mixing.—Mortar can be mixed best in a mortar mixing

machine. The period of the machine mixing should not be less than five minutes after all materials, including water, are in the mixer. When hand mixing is necessary it should be done in a water tight mortar box and the materials mixed dry until the entire mass is uniform in color. Water is then added

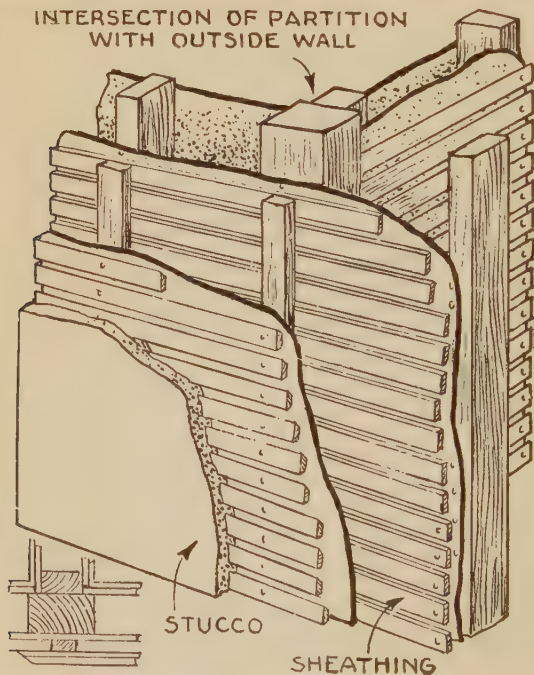


FIGS. 5,115 and 5,116.—Stucco applied to new frame building. 3, over two layer horizontal strips (so called wooden lath).

and the mixing continued until the consistency is uniform throughout. Use only enough water to produce a workable mix. The less water used within working limits, the better the quality of the mortar. Mortar which has begun to stiffen

or take on initial set should not be used. Mix only the amount of mortar that would be used within thirty minutes.

Procedure.—The plastering operation is to be carried on in one general direction without permitting the mortar to dry at the edges. If impossible to finish a full wall at one time,



FIGS. 5,117 and 5,118.—Stucco applied to new frame building. 4, over two layers of horizontal trips separated by vertical furring.

the joints should be made at some natural division of the surface such as a pilaster, door or window.

First Coat.—A first or “scratch” coat should have an average thickness of $\frac{1}{4}$ inch over the lath, or base. It should be well

trowelled into the lath, or base, to obtain a thorough bond or key. This coat should then be heavily cross-hatched to provide a strong mechanical key for the next coat.

Second Coat.—The second or “brown” coat should be ap-

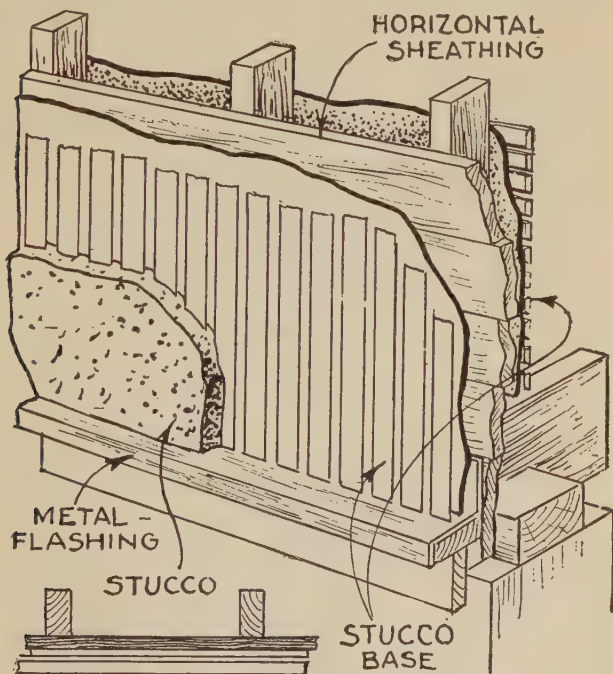


FIG. 5,119 and 5,120.—Stucco applied to new frame building. 5, over horizontal sheathing.

plied the day following the placing of the first. The first coat should be dampened, but not saturated, before the application of the second coat. The second coat should be from $\frac{3}{8}$ to $\frac{1}{2}$ inch thick, and should be brought to a true, even surface by frequent testing with a straight edge. When stiff enough, it

should be floated with a wooden float and lightly and evenly cross-hatched to secure a good mechanical bond for the finish coat. The surface should then be sprayed and wetted and kept from drying out for at least three days.

Two-Coat Work.—Whenever two-coat work is required, the

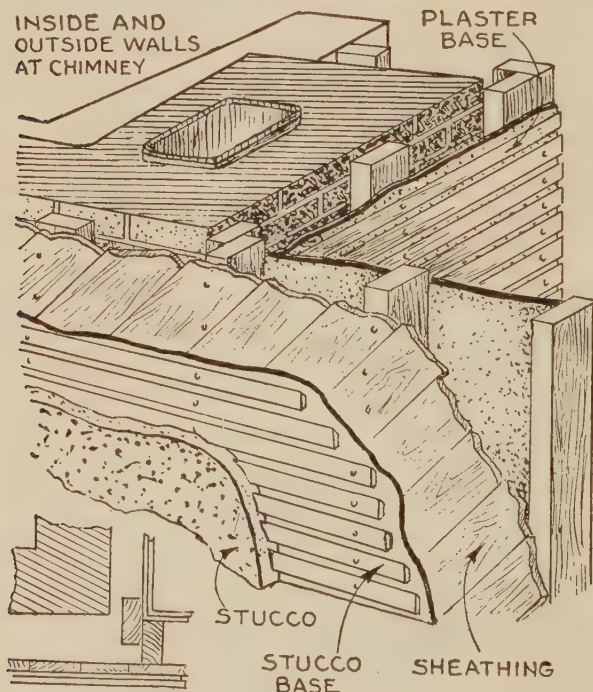


FIG. 5,121 and 5,122.—Stucco applied to new frame building. 6, over diagonal sheathing.

first coat should preferably be “doubled”—that is, as soon as the first coat is stiff enough it should be followed by a second application of mortar, and this should be treated as described under “Second Coat.”

Back-Plastered Work.—In back plastered work, the backing coat is preferably applied directly following the completion of the brown or second coat. The keys of the scratch coat should be thoroughly wetted and the backing coat immediately applied to a thickness of $\frac{5}{8}$ inch and should be finished $\frac{1}{4}$ inch back of face of studs.

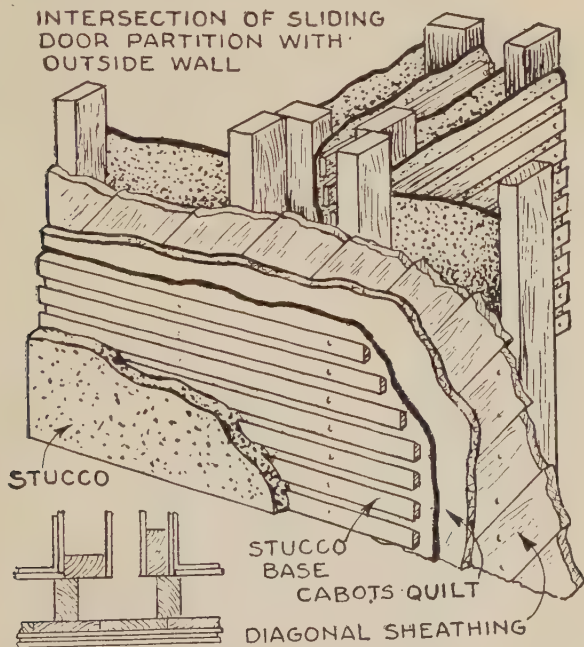


FIG. 5,123 and 5,124.—Stucco applied to new frame building. 7, over diagonal sheathing and cabots quilt.

Finish Coat.—The finish coat should not be applied until at least one week after the application of the second coat. The finish coat serves only a decorative purpose and has no structural value. Its function is solely to provide an attractive appearance, and any mixture or any method of application that

may detract from the appearance or in any way injure its permanency should be avoided.

Curing.—The curing of all under-coats by sprinkling and the protection of the finish coat against sun, wind, rain or frost by the use of tarpaulins, is always to be recommended. All

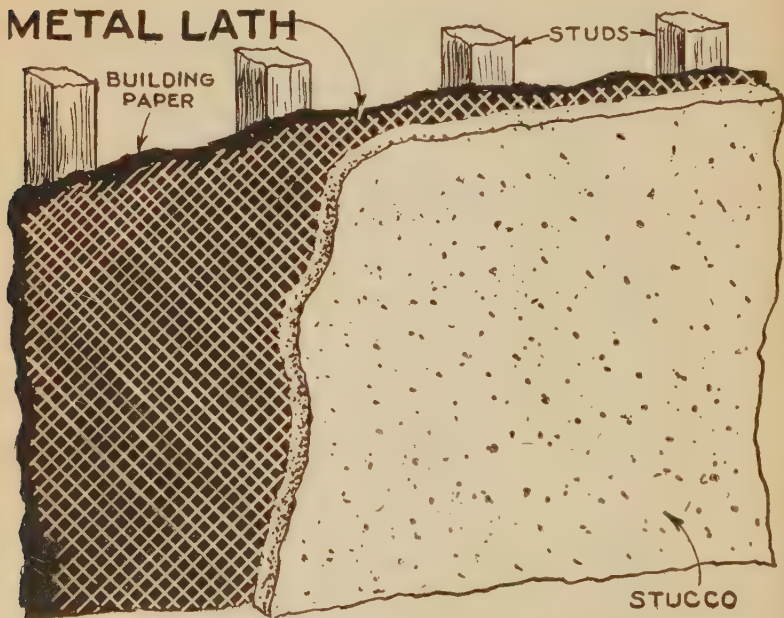


FIG. 5,125.—Stucco applied to new frame building. 8, over metal lath.

coats should be permitted to dry out very slowly, retaining their original water content as long as possible.

Freezing.—Stucco should not be applied when the atmospheric temperature is below 32 degrees F. If necessary to

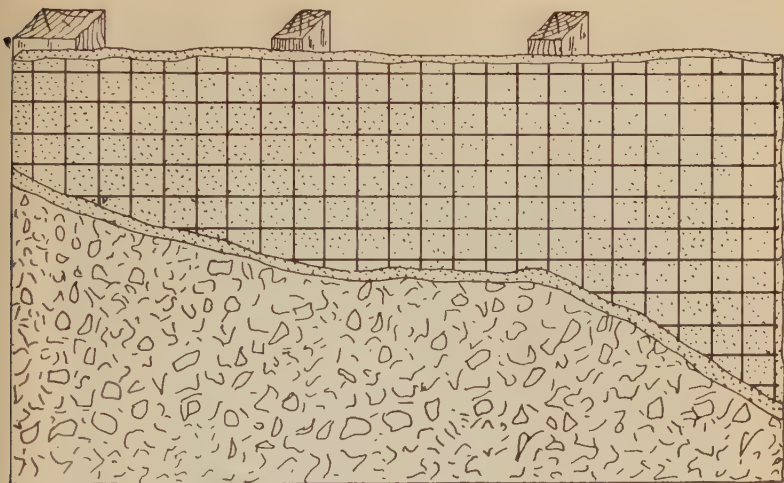


FIG. 5,126.—Stucco applied to new frame building. 9, over wire fabric.

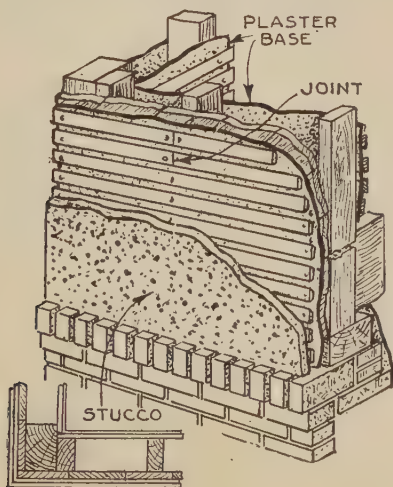


FIG. 5,127.—Stucco applied to new building. 10, broken joints.

complete a small portion of the job in cold weather, canvas should be used to protect the newly placed stucco from freezing.

Finish.—There are numerous kinds of finish given to the



FIGS. 5,129 to 5,131.—Three types of bases. Fig. 5,129, wood lath; fig. 5,130, metal lath; fig. 5,131, National steel wire fabric.

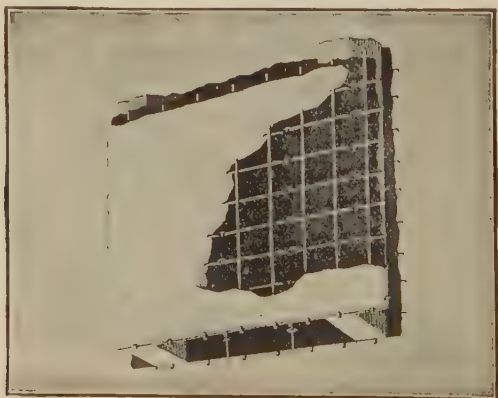


FIG. 5,132.—Stucco on National steel fabric.

surface of the stucco of which the following varieties of surface finish are extensively used.

Stippled Finish.—A stippled finish is obtained by lightly

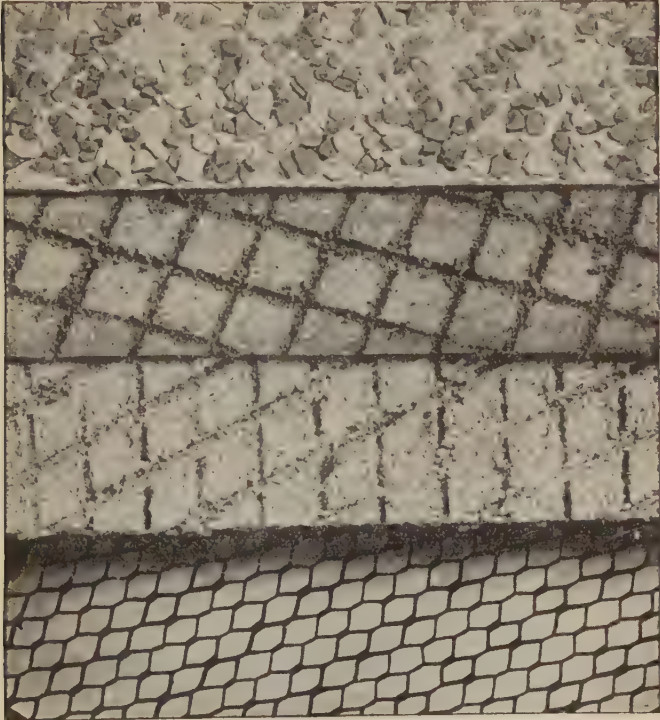


FIG. 5,133.—Successive steps in the application of three course stucco on metal lath. The heavy cross hatched scoring of the two base courses provides excellent bond for the succeeding course and for pebble dash finish.

patting the finishing coat with a brush of broom straw to give an even, stippled surface.

Rough Cast or Spatter Dash.—A mixture of one sack of

cement to 3 cubic feet of fine aggregate is thrown forcibly against the newly placed finishing surface to produce a rough, uniform texture when viewed from a distance of 20 feet. Special care should be taken to prevent rapid drying out of this finish by thorough wetting down at intervals after the stucco



FIG. 5,134.—Stucco on National steel fabric as applied over siding of old house.



FIG. 5,135.—National steel fabric applied to exterior wall for new or overcoat work, showing recommended method of doubly reinforcing corners of window frames.

has hardened sufficiently to prevent injury. A variety of spatter dash finish can be secured by using colored aggregate.

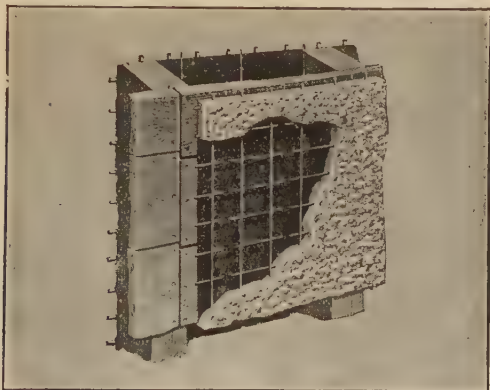


FIG. 5.136.—Stucco on National steel fabric as applied over wood sheathing or insulation. When so applied it should be put on with the crimps facing the sheathing and stapled with a one inch galvanized staple every 16 ins. longitudinally and every 6 ins. transversely. When applied to metal supports the fabric should be tread thereto by No. 16 gauge galvanized wire, at least every 6 ins. along the supports. Make laps by overlapping the face of the fabric one inch; do not butt the sheets. When applied direct to studs the sheets should extend at least to the first stud on connecting wall. Make no joint between studs.

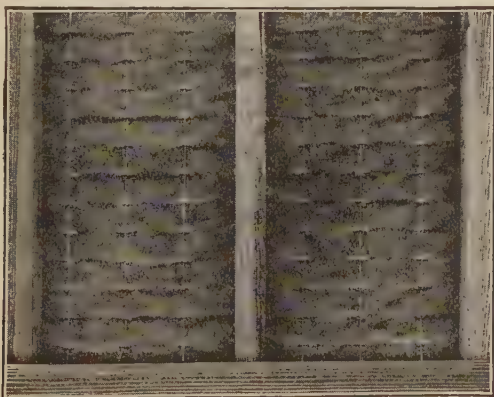


FIG. 5.137.—Stucco on National steel fabric as seen from back side when fabric is applied direct to studs.

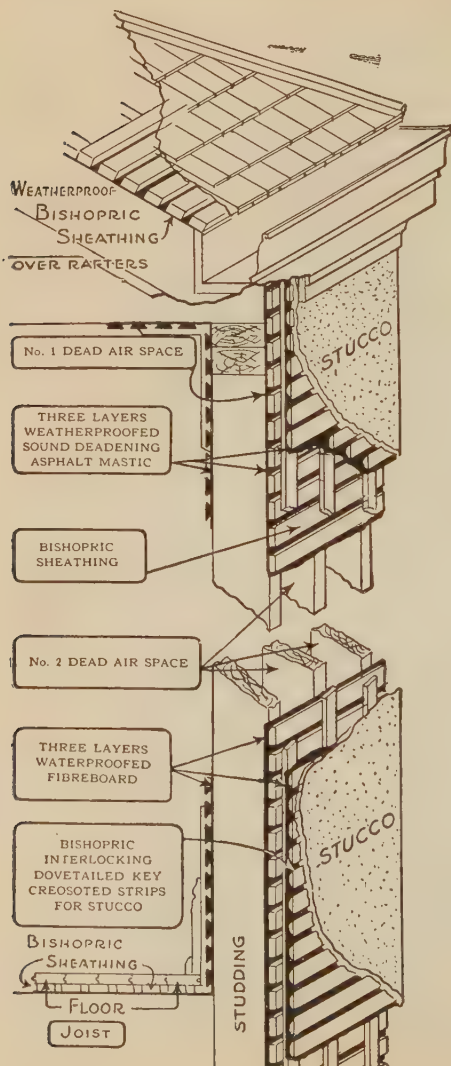


FIG. 5,138.—Stucco house construction as recommended by Bishopric, showing exterior stucco walls over two layer wooden lath and furring, interior stucco walls over wooden lath. A study of the illustration shows three layers of asphalt building paper and two layers dead air space.

Pebble Dash.—Before the finishing coat has begun to harden, clean round pebbles or other material as selected, not smaller than $\frac{1}{4}$ inch or larger than $\frac{3}{4}$ inch, previously wetted are thrown forcibly against the wall so as to embed themselves

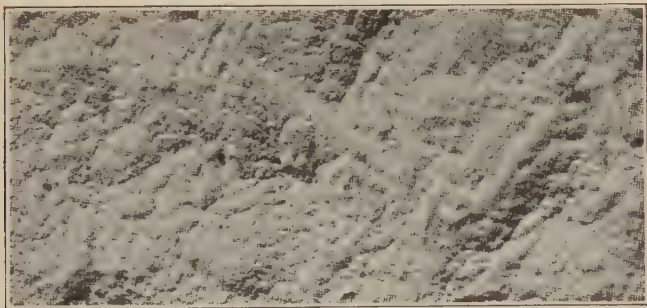


FIG. 5,139.—*Rough cast finish.* Obtained by roughing the surface of the finished coat with the trowel while the stucco is still soft.

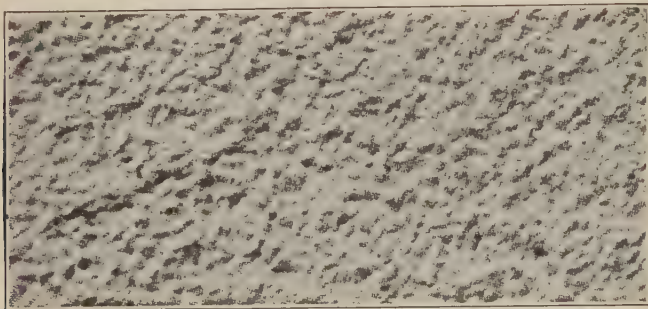


FIG. 5,140.—*Stipple finish.* Obtained by smoothing with a metal trowel, rubbing as little as possible, and then lightly patting with a whisk broom to give an even stippled surface.

in the fresh mortar. They should be distributed uniformly over the surface of the final coat and pushed back into the mortar with a clean wood float. No rubbing should be done after the pebbles are embedded.

Exposed Aggregate.—The finishing coat is composed of an approved, selected coarse sand, crushed marble or granite or other special material, in the proportion given for finishing coats. Within 24 hours after being applied and troweled to an even surface, it is scrubbed with a stiff brush and water.

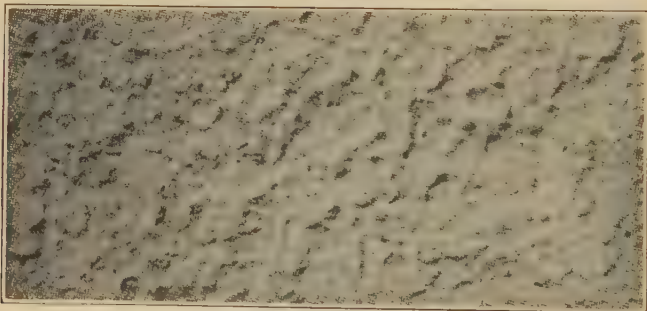


FIG. 5,141.—*Spatter dash finish.* Produced by tapping a long bristle, straight handled brush against a bar of wood so that a thinned mixture of the stucco will spatter against the surface after the second coat has been applied and before it has fully set.

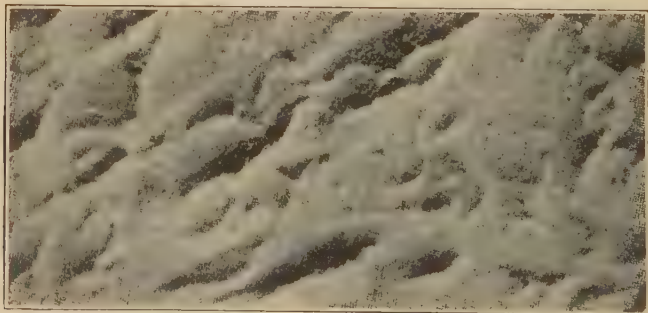


FIG. 5,142.—*Rough suction finish.* Obtained by roughing the surface of the finished coat with the trowel while the stucco is still soft.

If the stucco be too hard, a solution of one part hydrochloric acid in four parts of water by volume can be used. After the scrubbing, all traces of the acid should be removed by thorough spraying with water from a hose.

Sand Floated.—A sand floated finish is obtained by rubbing the finishing coat with a circular motion of a wood float, a little sand being added to slightly roughen the surface. This floating should be done when the mortar has partly hardened.

Sand Sprayed.—A sand sprayed finish is obtained by spraying on with as much force as possible, by means of a long fibre brush or whisk broom, a creamy mixture of equal parts of

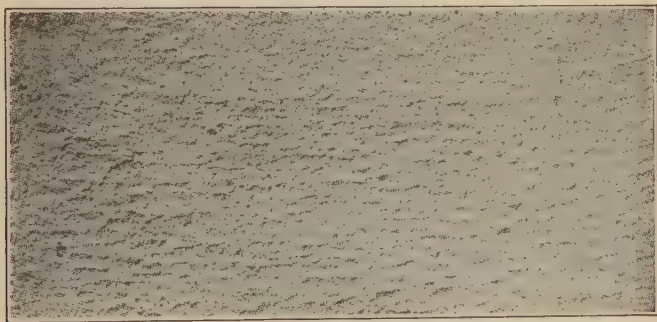


FIG. 5,143.—*Float finish.* The finishing coat, after being brought to a smooth even surface is rubbed in a circular motion with a wood float, the floating being done when the stucco has partially set.

cement and sand, mixed fresh at least every 30 minutes and kept well stirred until used. This treatment should be applied before the finishing coat has attained its early hardening, that is, within three to five hours. The addition of hydrated lime not to exceed 10 per cent of the weight of the cement in the mixture, will produce lighter shades of finish.

Smooth Finish.—The finish coat should contain all the material desired in the finished surface. The troweling of the finish coat should be continued until the desired smoothness and texture is obtained, but should be the least possible to

produce this surface finish. Particular attention to proper curing methods is absolutely necessary to obtain the best results with this type of finish.

Sponge Finish.—Immediately after the finishing coat has



FIG. 5,144. —*Sand spray finish.* After the finishing coat has been brought to an even surface, it should be sprayed by means of a wide, long fibre brush—dipped into a creamy mixture of stucco and sand, mixed fresh at least every 30 minutes, and kept well stirred. This coating should be thrown forcibly against the surface to be finished.

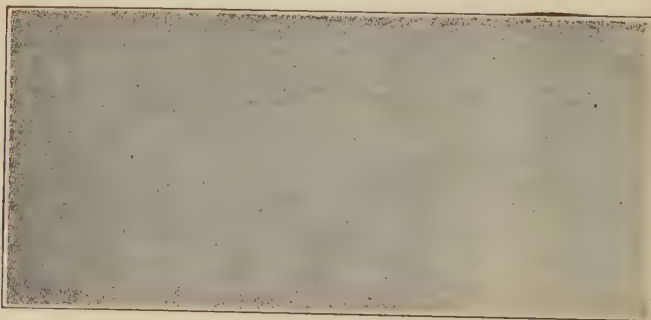


FIG. 5,145. —*Trowel finish, smooth.* Obtained by smoothing the surface with a trowel.

been brought to an even surface, a clean, soft pine float is pressed down onto the surface and withdrawn, care being taken not to separate the surface coat from the undercoat.

Construction Details.—An overhanging roof or similar projection is recommended to keep water away from the stucco and prevent dirt marks. Horizontal surfaces exposed to water should be avoided. All exposed stucco surfaces should shed water quickly. Suitable flashing should be provided wherever projecting wood trim occurs and should be continuous on wall copings, corners, rails, etc. Positive means should be provided to keep water from getting behind the stucco. Down spout hangers, gutters and other fixed supports should be in place

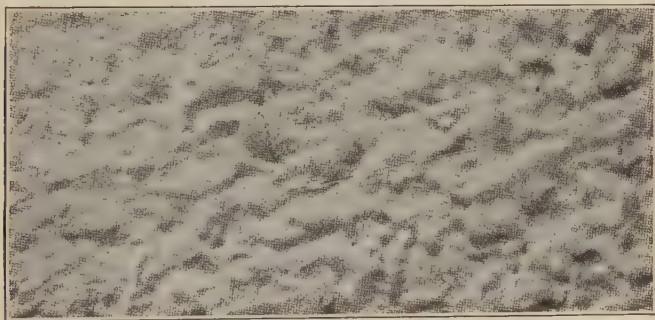


FIG. 5,146.—*Sponge finish.* Trowel or float to a smooth surface and immediately finish with a coarse sponge, using the sponge in the same manner as a stippling brush. It is necessary that the sponge be moist, but not wet all the time that it is being used, and that it be kept clean and free from particles of stucco by frequently rinsing.

before applying the stucco. Typical construction details are shown on page 682.

Masonry Walls.—All masonry walls should be thoroughly cleaned free from dust, dirt and loose particles and wetted to such a degree that water will not be absorbed from the stucco.

Concrete Walls.—Monolithic concrete walls should preferably be rough and of coarse texture rather than smooth, for

the application of stucco. Such walls may be roughened by picking, hammering with a pneumatic hammer or by an acid wash treatment.

Concrete Block and Concrete Tile Walls.—The surface of concrete block to be stuccoed should be rough with coarse texture to increase the bond of the stucco, but the block

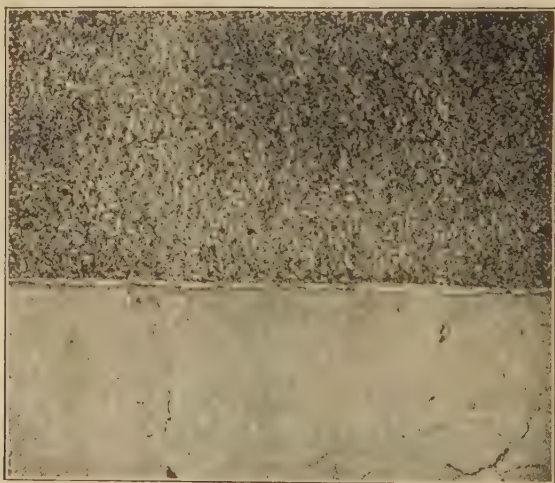


FIG. 5,147.—Stucco peeling due to no bonding on smooth cement. The attempt to apply magnesite stucco on a smooth cement plastered surface is frequently attended by failure.

should be of good quality. Mortar joints should be raked out or cut back at least even with the surface.

Brick Walls.—Surface brick to be stuccoed should be rough, hard burned and of good quality. Mortar joints should be not less than $\frac{3}{8}$ inch thick, and the mortar should be raked out for at least $\frac{1}{2}$ inch from the face.

Clay Tile Walls.—Tile should be hard burned with heavy scoring and should be set with exterior faces in line. Joints should not be raked out but mortar should be cut back to surface.

Frame Walls.—Stucco on sheathed frame construction is not intended to add greatly to the rigidity of the building.



FIG. 5,148.—Stucco rotting on white sand lime brick. Do not put magnesite stucco on white sand lime pressed brick as disintegration such as here shown is almost certain to follow. Not only does the lime in the brick react with the magnesium chloride in the stucco, destroying its bonding action so as to resemble rotting, but these brick themselves have a tendency to soften and spoil in exposed places.

Diagonal bracing should be used at corners of walls and the details of the frame work given attention to reduce the vibration in the structure to a minimum. Bridging should always be used for the back plastered type for which sheathing is omitted.

Sheathing should be horizontal and not diagonal. It should be firmly nailed to the studs and covered with a good quality tar or asphalt paper with plenty of lap between sheets and at baseboard and flashing. Furring should be $\frac{3}{8}$ inch crimped and should be fastened over the sheathing paper directly along the lines of studs with $1\frac{1}{4}$ inch staples 12 inches apart. Furring should be placed entirely around all openings and around curved surfaces.

Where metal furring for back plastered construction is used it should be



FIG. 5.149 —Byrckett sheathing lath trouble. The lath is the source of strain at the joint of the boards which results scoring as shown; moreover the lath is usually made of pitchy yellow pine lumber which causes poor bonding of the stucco.

be stapled to studs at intervals not greater than 12 inches with $1\frac{1}{4}$ inch by 14 gauge staples. Self-furring lath should be rigidly fastened to the studs with staples.

Metal lath should be galvanized or painted expanded metal weighing not less than 3.4 pounds per square yard, or galvanized or painted woven wire not lighter than 19 gauge, $2\frac{1}{2}$ meshes to the inch and stiffeners at 8 inch intervals.

Vertical laps of metal lath should be at supports and fastened with staples 4 inches apart. Horizontal joints should be locked, butted, or tightly laced with 18 gauge galvanized wire. Sheets of metal lath should be folded around the corners and firmly stapled down. Corner beads should not be used.

Additional insulation may be given to back-plastered walls by fastening felt fibre or cork insulating sheets to the studs between the back-plaster coat and the interior finish. A heavy grade of good building paper may be

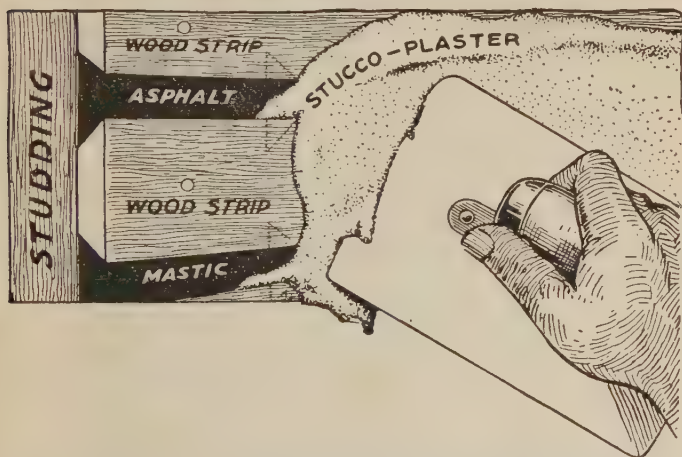


FIG. 5,150.—Application of stucco to Bishopric base of dovetail wood strips and asphalt mastic, showing how the stucco is locked or keyed by the dovetail shape of the strips. The wood strips are treated with creosote to prevent decay. The object of the asphalt mastic is to prevent dampness reaching the frame.

used for this purpose but should be so placed as to leave an air space between it and the stucco.

Old frame structures to be stuccoed should be made strictly sound and rigid before applying the stucco.

Points on Coloring Pigments.—Depth of the shade produced by mineral colors can be secured only by mixing the materials for a longer time than would be required in work in which

color is not used. Magnesium fluosilicate has also been used with apparent effectiveness in setting the color in the stucco.

Red oxides of iron produce the most durable red tints. Venetian red should be avoided, as it tends to run and fade. Manganese oxide is probably the best material for black, although a high grade of carbon black or lampblack is generally satisfactory. Common lamp black should not be used.



FIG. 5,151.—Stucco failure due to corrosion of metal lath. *The illustration shows* the destructive effect of using the ordinary metal lath with magnesite stucco. The time of this disintegration was four years. Nothing remained of the metal but zig-zag furrows of iron oxide rust. *Metal lath should be galvanized.*

Applying Dash Aggregates.—To secure a uniform finish a great deal of care must be taken. Dry, fresh dash which has been screened, must always be used. Do not gather dash up from the ground and throw to the wall with clean, fresh dash.

Ordinarily it requires two workmen to apply the Finish

coat, one using hawk and trowel; the other following, throwing the dash. The warmer the weather the more essential it is to follow immediately with the dash.

Dash can be carried in a clean, dry, small box or pail.

In applying the dash the best results are obtained by using a broad wooden or steel paddle about 6 inches long and 7 or 8 inches wide.

Stretch a canvas, or drop cloth, along the side of the building to catch the surplus dash, or a scaffold cloth may be used.

In the application of the various coats, roughen the first or scratch coat thoroughly before the second coat is applied. Keep each coat damp before the application of the following coat.

Never use retempered stucco (stucco which has begun to set and is then moistened). Always mix the various ingredients thoroughly in small batches at a time. Start plastering at the top, and carry it downward continuously, without allowing the stucco to dry at the bottom edge. If it be impossible to work the full width of the wall at one time, have the break at some natural division of the surface—window or door.

The following method is best in applying finish coat and dash to prevent joinings or laps in coming down the side of the wall with the $\frac{1}{4}$ inch finish coat.

There should be two workmen, one applying stucco with the hawk and trowel, the other following up closely throwing the dash—dashing completely to the lower edge of the stucco. When the workmen drop down to the next scaffold, they cut with the trowel just above the point to which the dash extends. Do not cut a straight line across the wall but let it be uneven in about the same way as you would naturally leave the lower edge of the work you are doing.

When the finish coat is applied to the lower part of the wall it should be spread so as to leave a little space between the fresh finish coat and the edge of the joining. That is, leave about $\frac{1}{4}$ inch space between old and fresh material. Then take trowel and carefully run the finish coat up to the joining, being careful to get a level, clean job. Dash so that stone strikes on both sides of joining so that no joinings will show when completed.

Foundation Treatment.—A good substantial foundation is

the first essential to the permanency of any structure. A foundation properly built will provide against settling and sagging, thereby avoiding unusual stresses which are detrimental to all materials used in the structure, and often times causes serious trouble and considerable expense to remedy.

In cases where cement foundation is already in place and same has been finished with a smooth surface and it is desired to stucco a portion of the cement foundation, the surface of

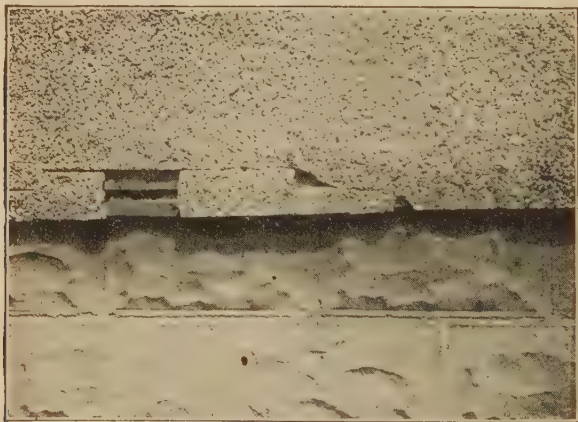


FIG. 5,152.—Cracking off of stucco due to omission of water table at the lower edge of the wall. The absence of water table not only gives an unfinished appearance but permits the entrance of moisture back of the stucco with the result here shown.

same should be well shipped so as to present a rough surface to allow of a bond between it and the stucco.

Where the base board is not used, concrete or brick foundations should never be stuccoed lower than a line 8 to 10 inches above the grade line.

It is bad construction to run stucco or any veneer coating down to or below grade lines.

The foundation should be built substantially, with an offset extension. A water table, base or drip cap should be provided at least 6 ins. above the grade line to prevent stucco from extending down to the grade. Care

should be taken that the sills of the building are properly placed and slushed with cement mortar so as to seal all openings from below or from the basement. This will prevent any moisture getting up around the sills to the back of the wall between the studding through capillary attraction, or continuous moisture. This is simply good construction and a safeguard for the interior plaster as well as for the exterior stucco.

Base Boards.—In case the foundation is not brought well above the grade line, $1\frac{1}{2} \times 8$, 10 or 12 in. base boards of clear cypress, white pine or clear redwood should be used at the grade line of the building. These base boards should be placed so that they will show an offset from the stucco. If the top edge be not bevelled, a water table may be used at the top of the base board if desired. In addition to giving a better finish, and architectural effect to the building, it will prevent the stucco being discolored by dirt being washed against it by rain, or being forced away from the building by frost getting behind the stucco.

The base boards should be painted on both sides and edges before being put in place to correspond to the trim of the building. They will last for years and are easily replaced when necessary. Stucco should never be run down to or below grade line.

Stuccoing to Ground Line.—Practically all instruction books have pointed out the fact that failure will result when the stucco is extended down to the ground line. Not only does the stucco become unsightly from the mud which splashes on it, but it disintegrates at the ground line because of the moisture which works up behind it. This trouble is not only avoided by the use of a water table and base board but the appearance of the building improved. Conditions of ground line failure are duplicated if the stucco be run to the floor of an open porch as shown in figs. 5,153 and 5,154.



FIGS. 5,153 and 5,154.—Open porch failure and close up of same. With such construction, snow and ice collect in winter on the floor of a porch which has no roof. *To avoid this* a base board should be used.

Flashing.—Suitable flashing should be provided over all door and window openings wherever projecting wood trim occurs. Wall copings, cornices, rails, chimney caps, etc., should be built of concrete, stone, terra cotta, or metal with ample

overhanging drip groove or lip and water-tight joints. If copings be set in blocks with mortar joints, continuous flashing should extend across the wall below the coping and project beyond and form an inconspicuous lip over the upper edge of the stucco.

Continuous flashing with similar projecting lip should be provided under brick sills. This flashing should be so installed as to insure absolute protection against interior leakage.

Cornices set with mortar joints should be provided with flashing over the top.

Sills should project well from the face of the stucco and be provided with drip grooves or flashing as described above for brick sills. Sills should also be provided with stools or jamb seats to insure wash of water over the face and not over the ends. Special attention should be given to the design of gutters and down spouts at returns of porch roofs where overflow will result in discoloration and cracking. A strip should be provided at the intersection of walls and sloping roofs and flashing extended up and over it, the stucco being brought down only to the top of the strip.

Preparation of Original Surface.—All roof gutters should be fixed, and downspout hangers and all other fixed supports should be put in place before the plastering is done, in order to avoid breaks in the stucco.

Pneumatic Mixing and Placing.—The pneumatic method of mixing and placing grout and concrete is in extensive use and in many instances results in a considerable saving of labor and time. A typical machine for performing these operations is known as the cement gun which is here described to illustrate the method. The cement gun as shown in figs. 5,158 and 5,159 is a pneumatically operated machine dependent on the flow of air to accomplish the desired results. This insures not only the conveyance of the material to the nozzle which may be located at considerable distance and difference in elevation from the

machine, but also the further additional and beneficial result of having the material propelled by this pressure against the surface to be covered, insuring a permanency and density far in excess of any other method. This also means the elimina-

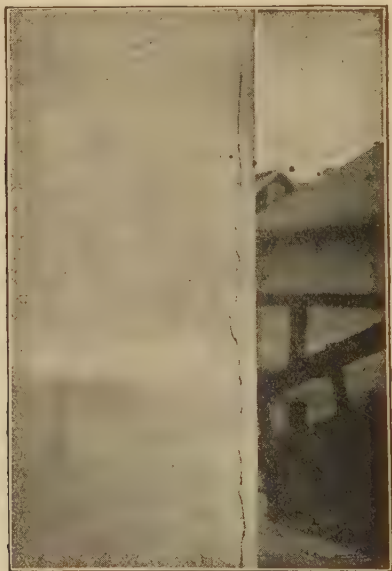


FIG. 5,155.—Unprotected corner. The corners of any building are the weakest parts of the structure and therefore require greatest protection. Many builders support the corners with galvanized chicken wire mesh.

tion of heavy and expensive forms, for the material builds up against the backing to a considerable thickness without injury.

In operating, the material is first mixed dry, and placed in the upper chamber of the machine from which it travels in consecutive stages to the lower chamber, and thence through the hose to the nozzle. It is well to bear in mind that a normal percentage of moisture in the sand (4% to 6%) is advantageous, as otherwise there is too great a tendency of the sand and cement particles to be segregated.

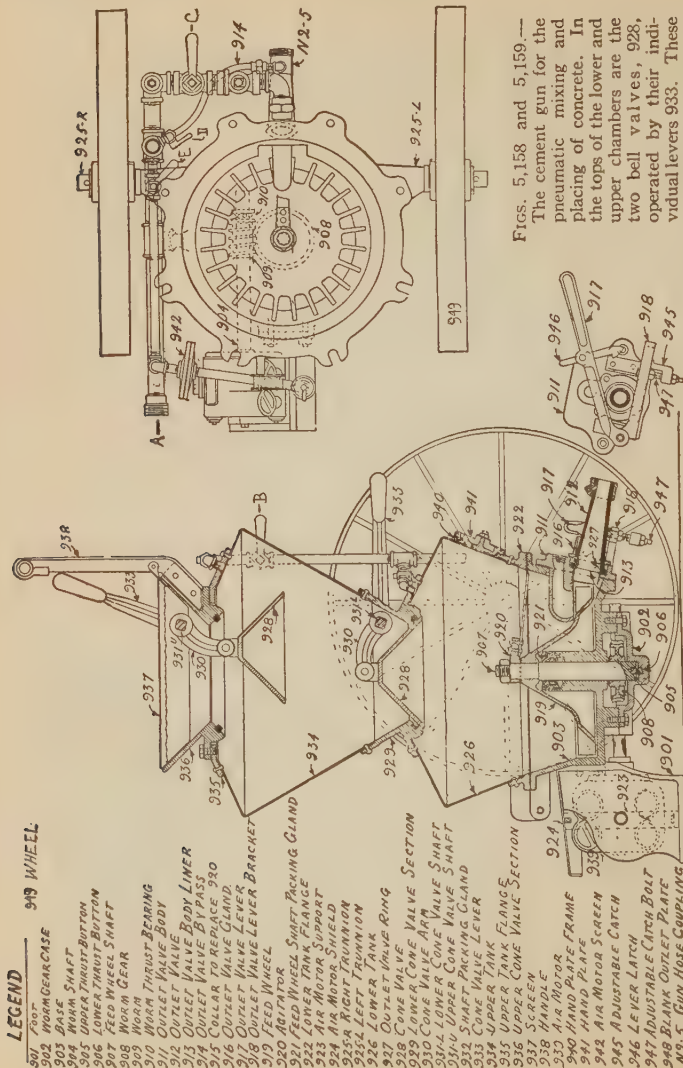


FIG. 5,156 and 5,157.—Failure of stucco on projecting ledge and close up of same. *With such construction* the stucco disintegrates rapidly for the reason that it cannot withstand the continual soaking and the frost action which occurs on such a location and its failure is certain even if a reinforcement of metal fabric be used or even if the backing be solid masonry.

The water is introduced through the walls of the nozzle in needle jets under higher pressure than the air, thereby causing these jets to puncture this stream of flowing material.

The action of the air in the main hose causes the water from these jets to become atomized, resulting in the





Figs. 5,158 and 5,159.

The cement gun for the pneumatic mixing and placing of concrete. In the tops of the lower and upper chambers are the two bell valves, 928, operated by their individual levers 933. These two chambers are kept

in equilibrium through their respective valve connections with the main header pipe. In the bottom of the lower chamber is the feed wheel 919, keyed to a vertical shaft, which in turn is keyed to and driven by a bronze worm gear 908, through a worm attached to the shaft of a small air motor 930. As this wheel revolves the pockets are brought under the influence of an additional jet of air admitted through the "gooseneck" which causes the material in these pockets to be blown out through the outlet valve 912, and thence through the hose to the nozzle or point of application.

covering of all the particles with this fine spray. When this hydrated material is impelled against the surface to be coated the first effect is to cause a very marked rejection of material, which, examination has shown, is sand only, showing that the cement has adhered to the surface forming a film of neat cement which acts as a matrix. When this matrix assumes a perceptible thickness the sand finds a seat, and the rejected material grows markedly less. There continues a certain amount of rejection of this inert material, each grain of which, however, has performed the function of acting as a tamper to drive the preceding grains deeper into the matrix in which they are seated. The result of this pounding action is to produce a very dense, hard and durable mortar.

Although this "rebound" has a definite and useful action, it also presents a difficulty which must at all times be reckoned with in order to insure proper and satisfactory work. It is the custom to use air at a pressure of about 35 lbs. at the "gun" under normal conditions of operation, and with from 50 to 100 feet of hose in use. This will mean that the impelled material will have sufficient velocity to result in the "rebound" being thrown back sufficiently to clear the reinforcing wires. If, on the other hand, too low pressure be used, this rebounded material lacks sufficient velocity, and causes it to fall behind the reinforcing wire in loose piles forming what are termed "sand pockets."

In cases where the material is "shot" into confined spaces similar conditions will arise unless care is exercised and methods developed to overcome this.

Compressed Air for Pneumatic Mixing and Placing of Concrete.—For types of machines using high pressure air, a compressor of standard type with a gauge pressure of 100 lbs. per sq. in. with a volume depending on the distance or discharge should be used in all cases. It should be remembered that a small surplus over the maximum amount required will give results which will more than pay for the additional cost of installation.

A common mistake made by those not familiar with compressed air, is in assuming that the rated volume of a compressor given in cubic feet of free air per minute is the same as the actual output in cubic feet of compressed air.

Atmospheric air is figured at a pressure of 14.7 lbs. per sq. in. and a compressor rated at 800 cu. ft. of free air per minute has an intake of that amount, but in order to produce a pressure of 100 lbs. the atmospheric air must be compressed to approximately eight times its normal pressure of 14.7 lbs. per sq. in. This would actually give a pressure of 117.6 lbs., which when allowance is made for losses due to heat and friction, gives the required pressure of 100 lbs. per sq. in., but reduces the output in like proportion, therefore a compressor rated at 100 lbs. gauge and 800 cu. ft. of free air per minute produces 100 cu. ft. of *compressed air* at 100 lbs. per sq. in. pressure.

CHAPTER 92

Concrete Blocks and Tile

The employment of concrete block and concrete building tile simplifies the work of both designer and builder, and gives the owner the advantage of rigid, permanent construction with a saving in both labor and material. The wall dimension of available units lend themselves conveniently to any desired design and makes calculations simple.

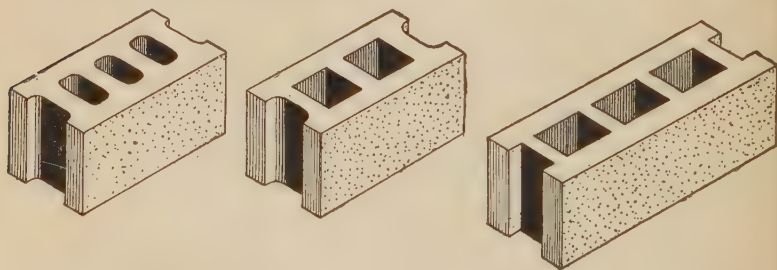
The day of the old imitation stone face attempted by use of a fantastic facing plate in the block machine, and which fooled no one, is passing.

If concrete blocks be properly made, no trouble will be encountered by the entrance of water through a wall constructed of these units. This involves that the type of block is such as to produce a wall having a continuous horizontal and vertical air space. This avoids sweating which would otherwise occur with variations of outside temperature. Unless this air space be provided by the use of hollow blocks, it must be obtained by means of furring and lathing. Concrete block and building tile lay up rapidly, bed firmly in the mortar and provide surfaces to which mortar and stucco adhere with great tenacity.

Walls of concrete blocks have the advantage over poured walls in that the blocks are thoroughly seasoned before they

are set and hence no provision is required for expansion or contraction. The expense of forms is avoided and also the tendency to crack and to leave an unsatisfactory surface finish. Concrete blocks may be substituted for any ordinary stone or brick masonry.

Rough cast concrete blocks form very desirable building units where it is intended finally to finish the exterior of a structure by applying a coat of stucco. Block buildings of this character may be erected at a cost which does not exceed a frame structure by more than 5 or 6 per cent, and a concrete block house is probably the lowest cost type of permanent fireproof building possible to construct.



Figs. 5,160 to 5,162.—Various types of hollow block.

Types of Concrete Block and Tile.—The principal types are classed as:

1. Hollow block.
2. Two piece block.
3. Building tile.

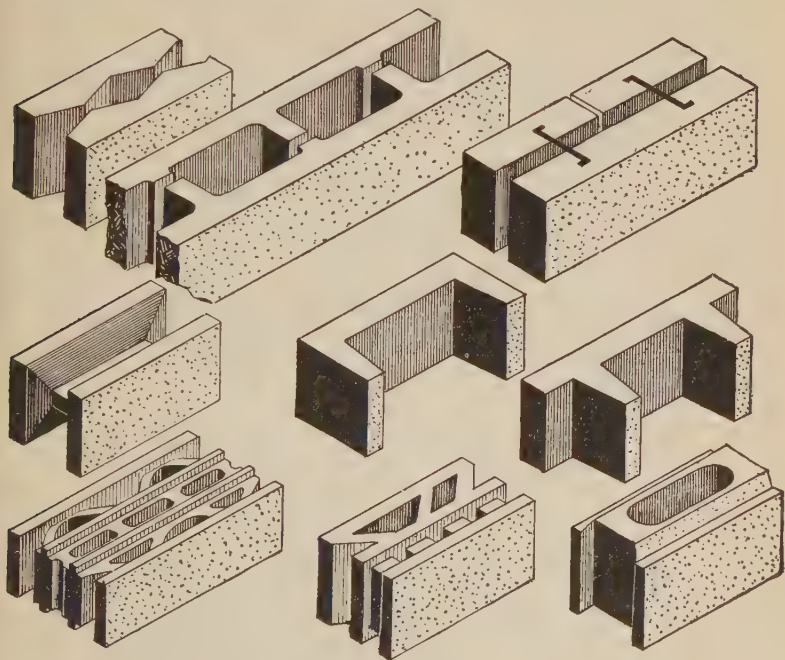
Hollow block have cells or air spaces running vertically through the unit as in figs. 5,160 to 5,162.

Two piece blocks as shown in figs. 5,163 to 5,166, provide a continuous air space in the wall. The inner and outer sections of the wall are bonded together in the block shown in figs. 5,164 and 5,166 by means of lugs or projections on the block which overlap in alternate courses.

In the block shown in fig. 5,163, the walls are held together with metal ties

that are imbedded in the block when it is made, while the block in fig. 5,165, the metal ties are placed in the mortar bed when blocks are laid.

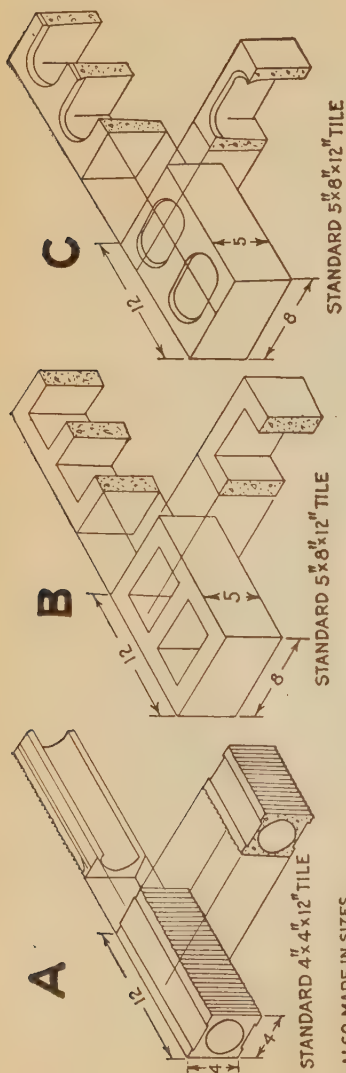
In both the hollow block and the two piece block the amount of air space varies from 20 to 40 % of their volume, but in most common types it approximates 33%. The tendency is to increase the air space to 40%, producing a lighter more economical unit.



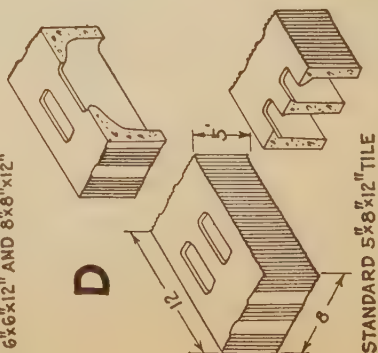
FIGS. 5,163 to 5,171—Various concrete blocks.

Where extra strength is required as in courses supporting heavy loads solid blocks are used, or hollow blocks made solid by filling the air spaces with concrete after the blocks have been laid.

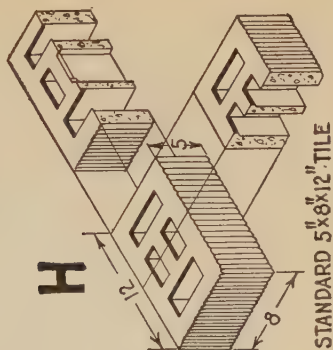
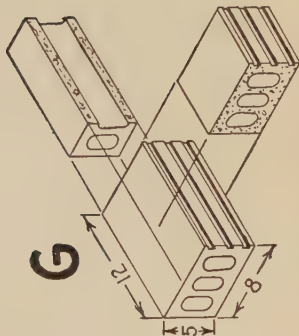
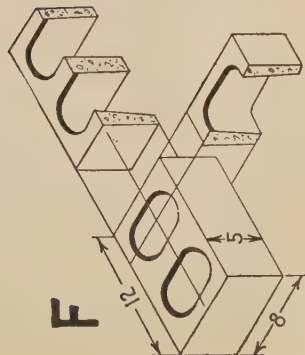
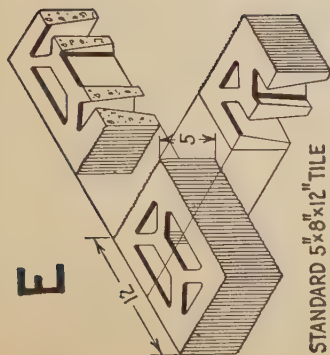
Size of Blocks and Tile.—They are made in various sizes. The 8×8×16 in. block is perhaps the most common. It



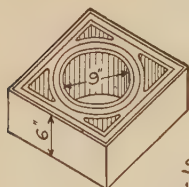
makes a wall 8 in. thick and courses 8 in. high. Blocks are also made regularly for building walls 10 and 12 ins. thick and with variations in height from 6 to 12 ins. and in length from 16 to 30 ins., the 8 and 9 in. heights and the 16 and 24 in. lengths predominating.



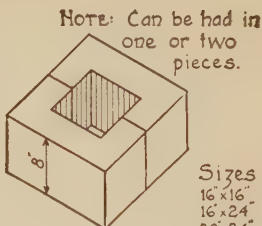
Figs. 5, 172 to 5, 183. — Various standard concrete building tile. **A**, duntile; **B**, lac tile; **C**, ideal tile; **D**, blystone tile.



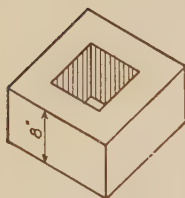
FIGS. 5,184 to 5,195.—Various standard concrete building tile—*continued*. **E**, high test tile; **F**, Besser tile; **G**, Eberling tile; **H**, McIntyre tile.



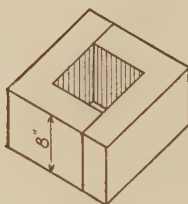
Sizes
16" x 16"
18" x 18"



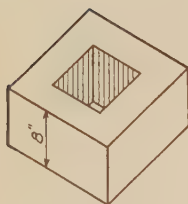
Sizes
16" x 16"
16" x 24"
20" x 24"
24" x 24"



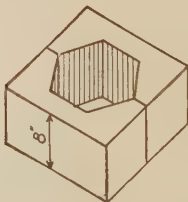
Sizes
16" x 16"
18" x 18"
20" x 20"
24" x 24"



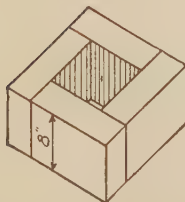
Sizes
16" x 16"
16" x 24"



Sizes
16" x 16"
20" x 20"



Size
12" x 12"



FIGS. 5,196 to 5,202. —Common types of concrete chimney blocks. **In chimney construction,** the foundation should be ample extending well below maximum frost penetration. Chimneys should never be carried on wooden joists or iron brackets or hung from rafter joists, or other wooden members. Blocks of house chimney should be well bonded into the house wall. For chimneys, use cement mortar mixed in proportion, 1 part cement to 2 parts sand.

Veneer and partition blocks are made 4 and 6 ins. thick and in common heights and lengths. Concrete building tile are usually smaller in size and lighter in structure than block, the standard size being $5 \times 8 \times 12$ ins. They are suitable for constructing walls either 8 or 12 ins. thick according to the way the unit is turned in the wall. In size and shape these concrete building tile resembled the terra-cotta tile, though the walls and webs are thicker. The foregoing are nominal sizes, thus a



FIG. 5,203.—Concrete blocks as a base for stucco. Portland cement stucco adheres readily to concrete block or tile.

block ordinarily spoken of as an $8 \times 8 \times 16$ in. size usually measures $7\frac{3}{4} \times 8 \times 15\frac{3}{4}$ ins., allowance being made for $\frac{1}{4}$ in. vertical and horizontal mortar joints. Most blocks 16 ins. in length or shorter are designed for $\frac{1}{4}$ in. joints although thicker joints may be used with no difficulty resulting, except that of the irregular dimension. Other block sizes are laid out for $\frac{5}{16}$, $\frac{3}{8}$ in. and other thicknesses of joint up to $\frac{3}{4}$ in. and some block moulds provide adjustments to permit varying the joints.

For economy of construction, it is well to make as general use as possible of "normal" or full size block of standard dimensions. Considerable saving can be effected by keeping wall lengths and door and window openings as nearly as possible in multiples of whole and half block. Corner block, joist

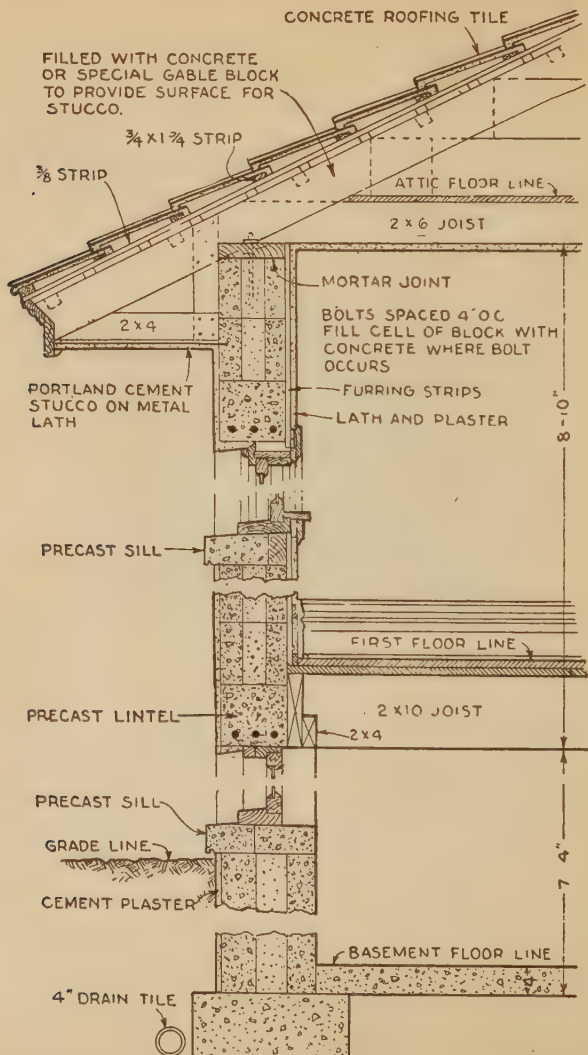


FIG. 5,204.—Sectional view of concrete block wall construction showing details.

block, sills, lintels and other special shapes are generally made in dimensions to accord with those of the normal block used in the wall.

Surface Finish.—There is a popular preference for stucco surfaces for houses and other buildings of moderate size because of the variety of artistic color and texture treatments available.



FIG. 5,205.—Concrete block with rough texture surfaces provide a backing to which Portland cement stucco clings tenaciously. The stucco cannot crack or separate from the wall.

Concrete block and tile provide the ideal backing for Portland cement stucco. The surfaces of these units are sufficiently rough to produce a strong mechanical key and their density may be regulated to give uniform, effective suction.

Thus figs. 5,205 and 5,206 show rough block and scored tile respectively

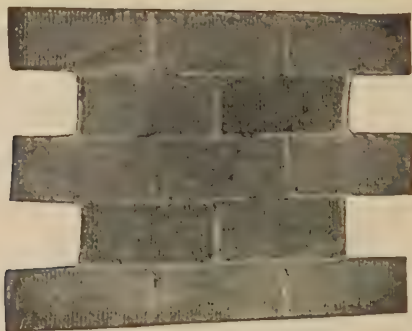


FIG. 5,206.—Concrete building tile with scored surface employed as a backing for stucco finish.



FIG. 5,207.—Concrete block made to resemble stone. By using the proper selection of aggregate and coloring in the facing the block can be made to resemble granite, limestone or any other building stone.

giving an efficient keying surface for stucco. The rigidity of concrete masonry construction is an assurance against movement of the wall and consequent cracking of the stucco.

Attractively faced block with a modest display of precast concrete art stone have become a very popular combination for larger structures. Some of the most pleasing surface finishes

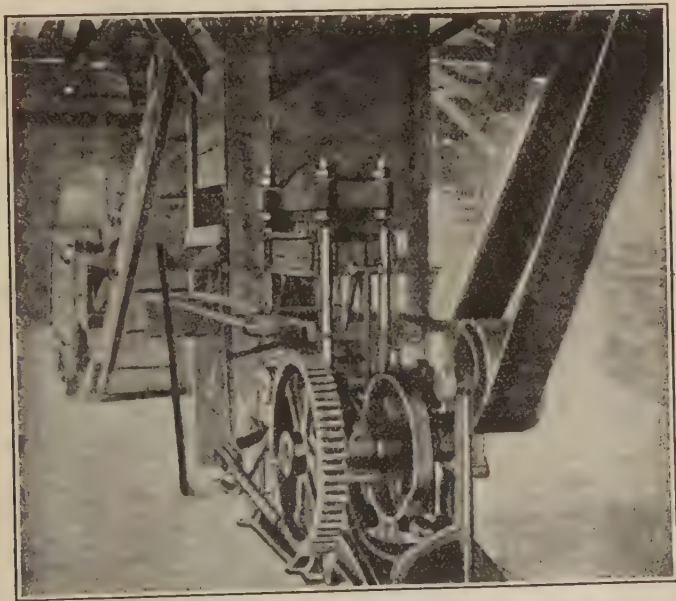


FIG. 5,208.—Interior view of Helm concrete block plant showing power press. At one end of the press is the charging hopper, beyond this, a belt elevator which lifts the material from the mixer to the hopper. With this arrangement one man handles the mixer, a second fills the conveyor boxes, the third operates the press, and the fourth does the off bearing from the press to the car.

are made by using selected colored aggregates in the facing. For example, white marble with a sprinkling of black marble or green-black copper slag, gives a surface which, when properly treated, resembles the costly natural marble.

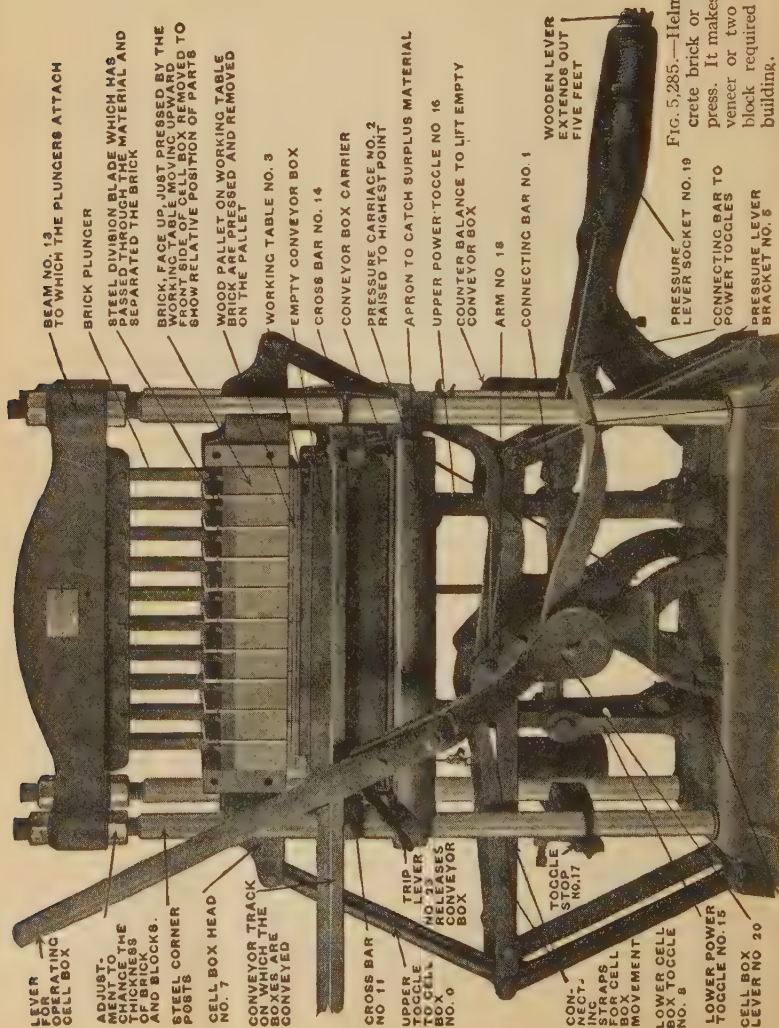


FIG. 5.285.—Helm concrete brick or block press. It makes any veneer or two piece block required in a building.

Buff pigment and graded marble chips with a sprinkling of mica spar produces a surface similar to limestone but with a life and sparkle resembling granite. Wide ranges of texture and color are available—including the entire range of marble, granite, colored sands and gravels and mineral pigments.



FIG. 5,210.—Frances concrete block, machine in operation releasing the finished block. Starting with the machine in position, *the operation is as follows:* The metal ties, which are essential in the moulding of this block, rest on the cross slots in the end cores, being locked in position with a metal key, so all the metal ties will be placed alike in all blocks. After the concrete is put in the mould box the key releases the wall ties. Fill all the concrete necessary to make a complete block into the mould box, $\frac{1}{2}$ -inch of rich material (one of cement, two of sand) for facing in front of the facing plate, and rough concrete (one cement, six sand and gravel) for backing behind the facing plate. The concrete is then tamped, top of mould struck off and machine lifted off the finished block, the sides falling apart automatically. There are no loose face plates to handle.

How Concrete Blocks Are Made.—There are several methods of making concrete blocks known as:

1. Dry process.
2. Wet process.
3. Pressure process.

In the dry process the blocks are made by tamping a dry concrete mix into shape in forms. The wet method consists in pouring a semi-liquid or *slush mix* into moulds and curing the product by air or steam. The third or pressure method is



FIG. 5.211.—Continuous air space block as made with Frances machine. *The block* consists of two slabs of concrete bonded together with four $\frac{1}{4}$ -inch galvanized steel rods bent up 1 inch at each end and moulded in the block. There are no concrete connections as shown between the outer and the inner slabs. There is a continuous air space that will allow the air to circulate perpendicularly and horizontally around the entire building, hence these blocks are especially well adapted for building in damp and cold climates.

a dry process in which mechanical or hydraulic pressure is substituted for the tamping.

Materials.—Sand, gravel, cement and water are the materials generally used for block making, the same as for any other form of concrete. The sand should be clean, fairly sharp and consist of grains of various sizes.

To determine if the sand be clear: 1, rub some of the sand between the hands and if they become badly discolored the sand is not clean and should be rejected; 2, drop a handful into a pail of clear water. If the water be clear enough to see the sand at the bottom in two minutes, it may be regarded as clean.

Gravel or crushed stone from $\frac{1}{4}$ inch up to $\frac{1}{2}$ inch, even a small

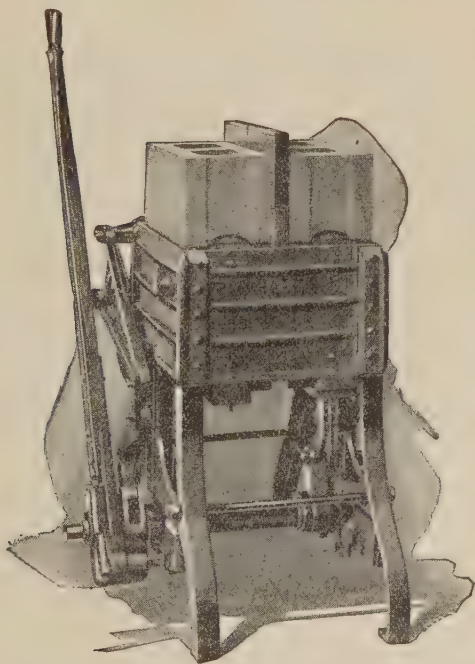


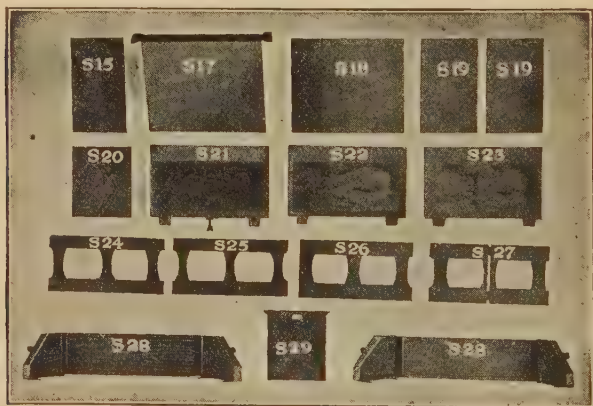
FIG. 5,212.—Multiplex double stripper hand power wet process block machine. Capacity with two men and material mixed 700 to 1,000 blocks per day. *In operation*, the machine is filled with the concrete, then scraped off level, then the lever is pulled down, which produces a 40-ton pressure from both top and bottom, then the lever is reversed, which ejects the block as shown in the cut. This trowels the block on all sides, and compacts it uniformly to the extreme edges, and all sides are square. The wet process avoids the expense of steam curing.

percentage up to $\frac{3}{4}$ inch can be used in connection with the sand when making blocks. For best results in block making, at least one-third of the material by weight should be coarser than one-eighth inch.

Clay in sand and gravel up to even 10 per cent has been found not to be detrimental, and some engineers even say a little clay is beneficial.

The best Portland cement should be used.

Slow setting cements which get their set from 4 to 9 hours are stronger than those which set more quickly. The water should be clean and free from acids, strong alkalis, or oils.



FIGS. 5,213 to 5,228.—Equipment for Multiplex double stripper hand power block machine. The illustration shows the different parts required for plain and rock face blocks, return corner and fractional blocks. Size of block $8 \times 8 \times 16$.

Proportioning the Materials—The proportions must depend largely upon the requirement that the blocks must meet. The proportion of cement to the aggregate will depend very much on the quality of the aggregate. A block made with one part cement to six parts aggregate might be better than one to four of another aggregate. A practical method of proportioning is to use a sack of cement as a unit for cement

measurement and use a bottomless box holding as many times the volume of the sack of cement as the proportion indicates.

In proportioning the water it should be remembered that the strength and density of the concrete will depend on the percentage of water used in the mixture. Where a dry mixture calls for 6 to 8% of moisture, the medium wet mixture calls for 10% when sand is moist, to 15% when sand is dry. There should be enough water uniformly distributed in the mass so that when a handful of the mixture is taken up and squeezed slightly, it will retain its shape when the hand is opened, but should not contain enough moisture so it can be squeezed out of the mixture.

There should be means of measuring the water as definitely as the other materials are measured. In experiments on dry, medium and wet mixtures it was found that the medium mixture was the most dense, the wet next and the dry last.

Mixing — There are two methods of mixing:

1. Hand mixing.
2. Machine mixing.

In the hand method, the shovelling should be done on a flat water tight platform, or other non-absorbing surface. The right proportion of sand or aggregate is first measured out. Spread it uniformly on the platform, place the cement on top, then mix the two until the mass assumes a uniform color.

By striking the back of the shovel across the material, the uniformity of color can best be determined.

The right percentage of water is then added, spraying it on as evenly as possible. The more evenly the water is added the less mixing will be required to secure uniform distribution.

A mixer can be added to the plant at any time. It will cut the labor cost of mixing from 50 per cent to 75 per cent. A mixer saves money in the end.

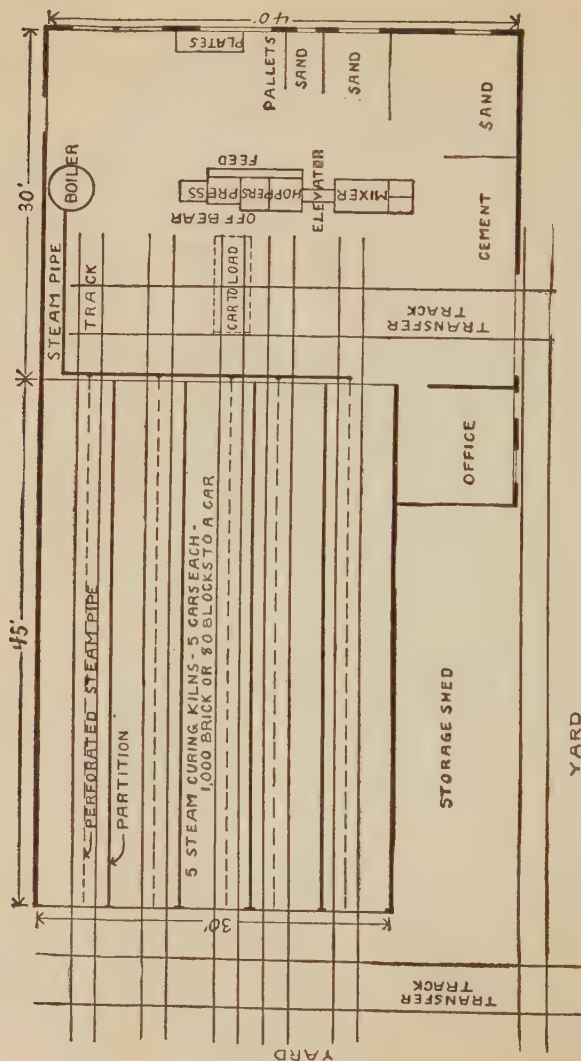


FIG. 5.229.—Helm pressed block plant of 1,000 block capacity per day. *In operation*, one man handles the mixer and furnishes all the concrete needed to supply the plant. A bucket or belt elevator takes the mixture as discharged from the mixer and elevates it into the feed hopper. The second man feeds the boxes at the hopper, the third man operates the press and the fourth man offbeats the product from the back table of the press to the car. This crew of men will produce 1,000 to 1,500 blocks daily with the help of 2 or 3 additional men to care for the product and yard it. The curing shed is divided into compartments. Steam pipes leading into the curing rooms should be placed on the floor and perforated about 18 ins. apart with $\frac{1}{8}$ in. holes so as to get good distribution of the steam.

Curing the Product.—After the product is formed and removed from the machine then attention must be given to curing it. All freshly formed concrete products should be placed in a curing room or shed to protect them from the sun.

When curing by the air drying system the product is thoroughly wet down once or twice a day for a week, and then allowed to finish curing without additional wetting. No water is applied until after the initial set takes place. The initial set will take place between two hours and four to six hours. It is good practice to watch for the edges of the product to turn light as this indicates that very light sprinkling is required. After the first day the product can be wet down thoroughly.

By having pallets for a two days' run the product can remain on the pallets for 48 hours, then it can be removed and placed in piles in the yard, where it can still be sprinkled once a day for the balance of the week. If there be plenty of curing room, the product can be removed from the pallet and cured right there. It should then finish curing and drying before sold. The greener it is when sold, the more carefully it will have to be handled. It should stand for two weeks to 28 days from the date of manufacture before being used, but the older it gets, the better it will be.

Steam Curing.—Crystallization takes place during the process of steam curing; this process converts the soft and plastic materials into a hard substance like stone.

Fig. 5,229 shows a series of curing rooms with its system of piping.

It is unnecessary to make the curing room very tight. In some plants instead of regular doors, canvas curtains are used. Not over five or ten pounds of steam need be carried and the temperature in the curing room is kept at about 100 degrees. The temperature can run a little higher with good results.

The product should be steamed for 24 to 48 hours. In small plants it is not economical to hire a man to watch the boiler at night and under such conditions the product can be steamed during the day run for two days. This cures it ready for removal on the morning of the third day, so the most practical way is to have sufficient curing room for $2\frac{1}{2}$ to 3 days' run.

Cement blocks when cured by this method will be as hard in 48 hours as



FIG. 5,230.—Helm "dry wall" concrete block with continuous air space. The wall is double each course, is usually 4 ins. thick. The air space is 2 ins. No cement bond obstructs this air space at any point. There is no concrete connection from exterior to interior to carry moisture and make a damp, unhealthy and insanitary building. Notice how the blocks bond and break joints. Rough blocks are used for the inner course and a block with a richer facing applied for the outer course.

air cured product in 7 to 15 days. The product can be taken directly from the kilns to the job, but it is better if allowed to stand in the yard for a few days. In some plants before the steam is turned on for the day the output is wet down thoroughly.

Wall Thickness.—

The thickness of concrete block walls is often regulated by state or local building codes. Eight inches is usually specified as the minimum thickness for exterior or load bearing walls. Partitions and curtain walls are often made only 4 or 6 ins. thick, but such skimping is not to be recommended.

The thickness of bearing walls in heavily loaded buildings is properly governed by the limits of loading. The allowable working loads on concrete block, when laid in lime cement mortar,

is commonly placed at $\frac{1}{10}$ of the average crushing strength or, when laid in cement mortar, at $\frac{1}{8}$ of the average crushing strength.

In dwellings, private garages and other small buildings, the actual loading of the units usually is much lower than this, frequently less than one-twenty-fifth of the crushing strength, but as before mentioned, a minimum wall thickness of 8 ins. is the general practice regardless of load.

The following table represents acceptable practice for walls of residences and apartment buildings (always only lightly loaded), except that the 10 in. block has been almost entirely replaced by the 8 in. block.

Thickness of Walls (Inches)

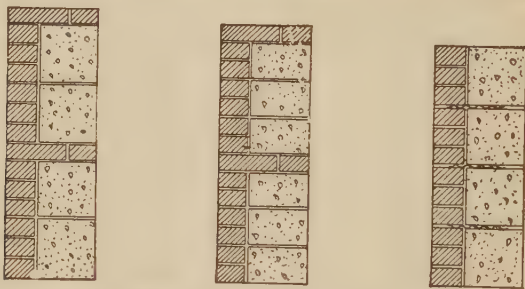
(For residence and apartment buildings where dead floor load does not exceed 60 lbs. per sq. ft.)

No. of stones	Base-ment	First story	Second story	Third story	Fourth story
1	8	8	..	..	..
2	10	8	8	..	..
3	12	12	10	8	..
4	16	12	12	10	8

Bonding with Brick Construction.—When concrete block and tile are used as a backing for brick veneer, the brick wall is usually bonded to the backing, by means of suitable metal strips or ties as shown in figs. 5,231 to 5,233, or cross bond may be obtained by using header courses of brick. Where the block wall is joined to a wall of brick construction, the units are laid as in fig. 5,234.

Eight inch courses of concrete block equal in height three ordinary brick courses. Five inch concrete tile courses equal in height two ordinary brick courses.

Corner Returns.—There are several accepted methods of



FIGS. 5,231 to 5,233.—Usual methods of bonding brick veneer to walls having a backing of concrete block or building tile. Fig. 5,231, bonding brick and block wall; fig. 5,232, bonding brick and concrete tile wall; fig. 5,233, bonding brick and block wall using metal ties.

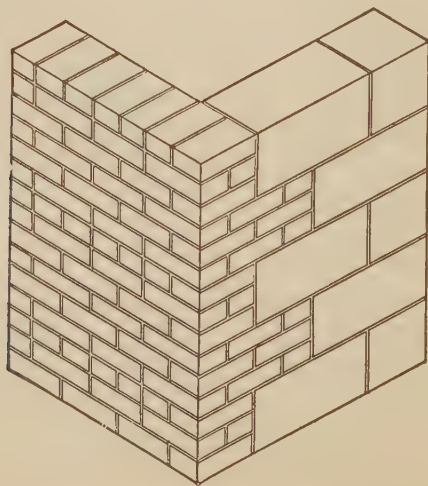


FIG. 5,234.—Method of bonding concrete block and brick walls.

making corner returns in block and tile construction, the choice being largely dependent on wall dimensions and the type of block or tile used. It is never necessary when making regular 90° corners to cut block or fill in with brick bats, and in the interest of neat construction such makeshift means should be avoided.

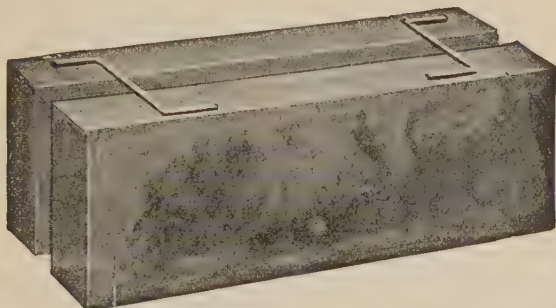
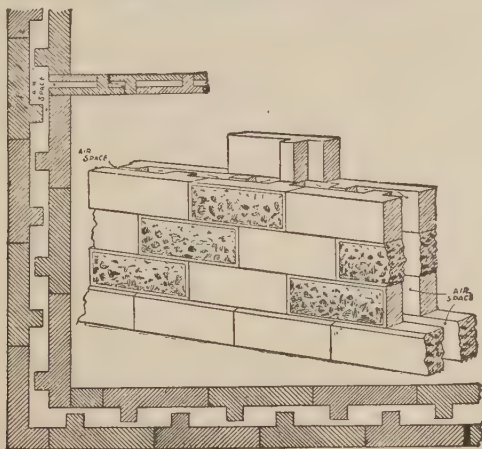
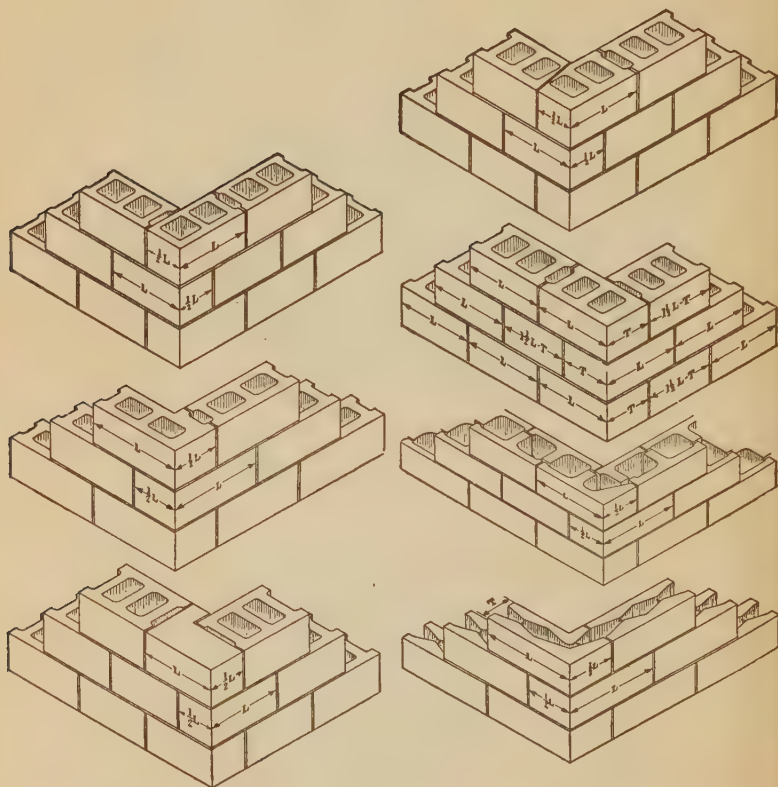


FIG. 5,235.—Helm continuous air space concrete block showing metal ties used instead of concrete ties to insulate the inner part of the block from moisture.



FIGS. 5,236 and 5,237.—Francis interlocking continuous air space concrete block wall construction showing construction of corner and partition.



FIGS. 5,238 to 5,244.—Various 90° corners with concrete blocks. The use of special blocks on the corners saves mason's time and better results are obtained. Most manufacturers carry complete stocks of corner blocks.

Mortar joints should break at the mid-joint as nearly as possible even in masonry which is to be covered with stucco. Certain irregularities may be permitted in stucco construction for the sake of economy since they will not appear in the finished work. For regular finished block work (that is, exposed blocks not covered with stucco) careful attention should be given to the joints.

The accompanying cuts, figs. 5,238 to 5,244, show 90° corners, with various types of block.

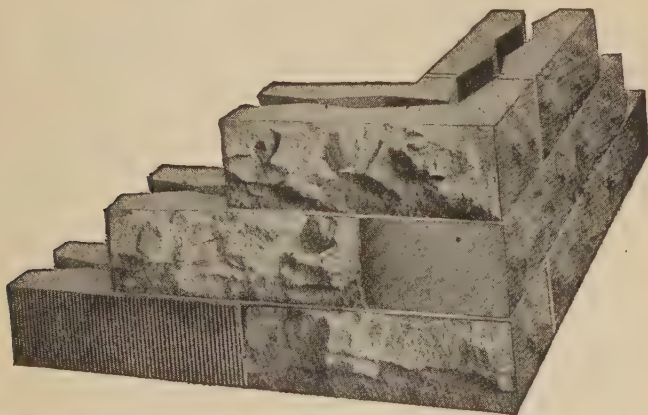


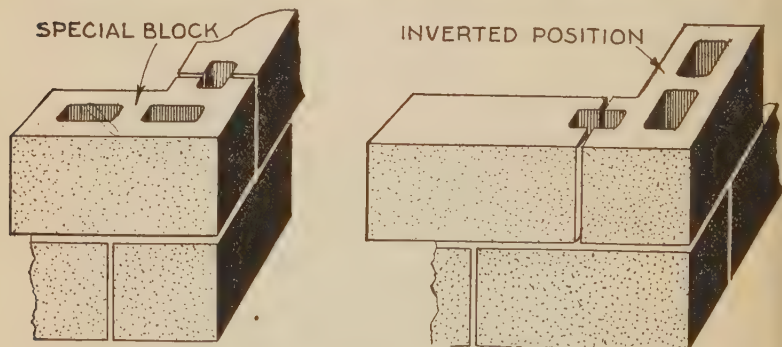
FIG. 5,245.—90° corner with Francis continuous air space blocks.

When the block thickness is greater or less than half the length special blocks are used, as in fig. 5,246. These specials are made reversible by inverting them as shown in fig. 5,247. Only one special unit is required in each course at the corner. Some other types of specials do not possess this feature.

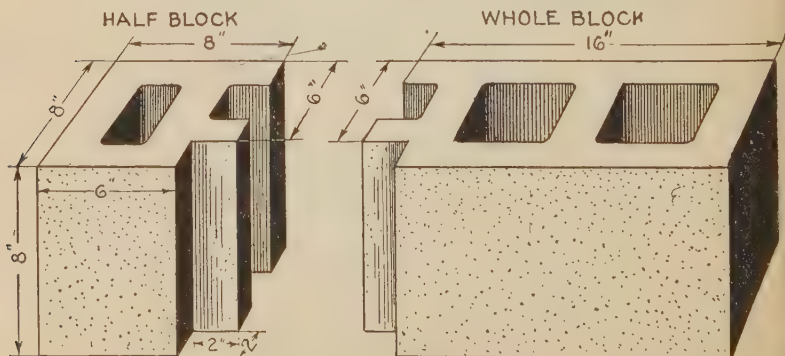
Fig. 5,242 shows one method of construction for corner where thickness of wall is greater than half the block length. As may be seen the joints next to the corner do not break at the mid joint but since the joint can be carried up consistently in a vertical line as long as blocks of the same thickness are used the slight irregularity is hardly noticeable.

Openings in Walls.—Door and window frames are usually built into the walls as the latter are laid. There are special blocks for windows and doors known as jamb blocks, as shown in fig. 5,248. They are supposed to fit plank and box frames of all common designs as shown in fig. 5,249.

Outside Fixtures.—At the time of laying concrete block or

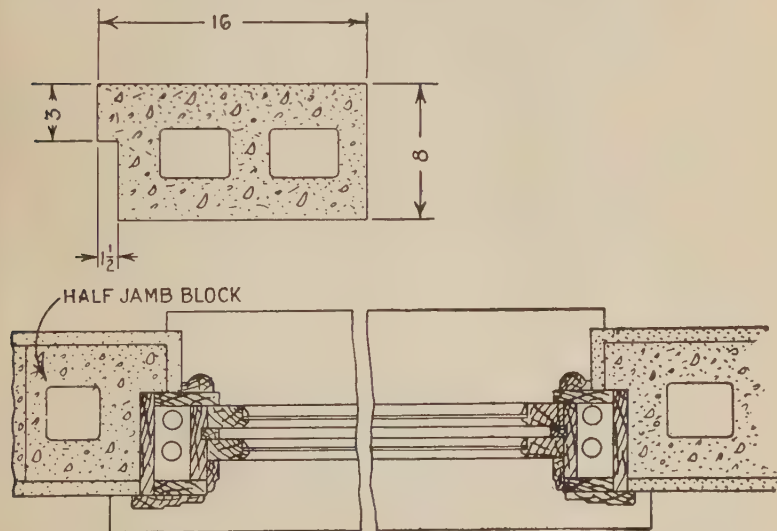


FIGS. 5,246 and 5,247.—Special corner block showing inversion of position for the different courses.



FIGS. 5,248 and 5,249.—Half and whole jamb block.

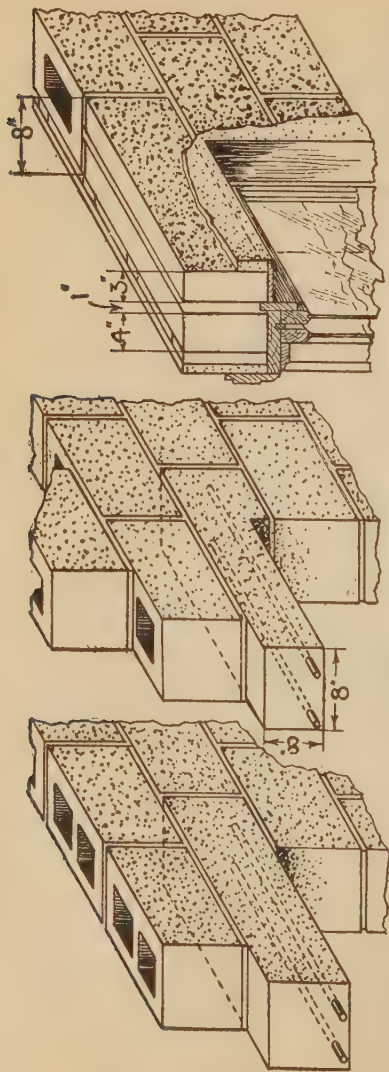
tile, provision should be made for attaching down spout brackets, telephone and electric service wires and other house fixtures on the outside of the walls. This avoids drilling holes later. A simple method to provide for such connections is to place short lengths of small lead pipe in the mortar joints into which expansion bolts may later be inserted. These inserts should extend outward so as to be flush with the finished



FIGS. 5,250 and 5,251.—Special door and window jamb block and application of same.

stucco when used. If pipe inserts be flattened out and care used, ordinary wood screws will hold. Screw anchors for masonry walls may be obtained.

Lintels.—Pre-cast lintels are generally more convenient and economical than lintels cast in place except possibly over wide spans where there may be a saving in clamping forms to the



FIGS. 5,252 to 5,254.—Standard lintel details. Lintels are usually made the same height as the block courses. That is, for say a block having an 8×8 cross section, a lintel with the same cross section is used. Reinforcement is always placed in lintels spanning openings of more than 3 ft., the steel bars being located about 1 in. above the bottom. Two ½-in. bars are used for a 4 ft. span, and 3 for a 5 ft. span.

wall and casting the lintel in place. Figs. 5,252 to 5,254 show standard lintel details.

Window Sills.—

These are usually pre-cast like lintels. They should have a steep “wash” or slope to the weather, project at least 2 ins. beyond the face of the wall, and have a groove on the underside to form a drip to keep water from flowing over onto the face of the wall. They are often set at the time the wall is built, but it is better practice to insert slip sills after the wall has been laid up. If built in, the joint below the sill should be left open and pointed up or filled after the wall has had a chance to settle, as otherwise the slightest movement will crack the sill.

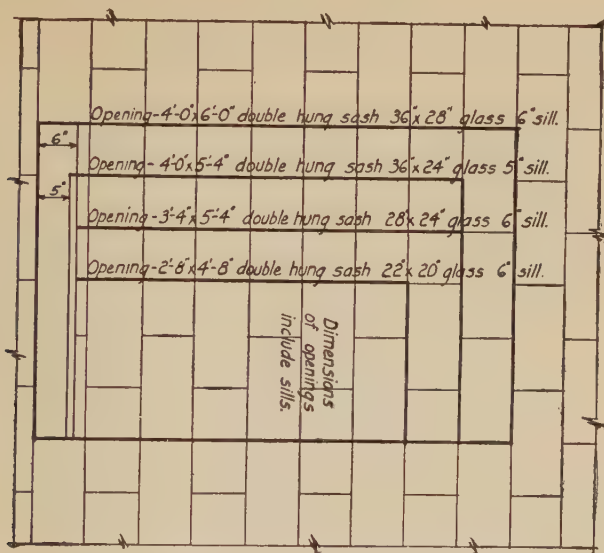
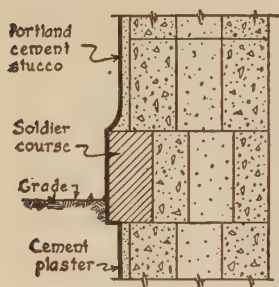


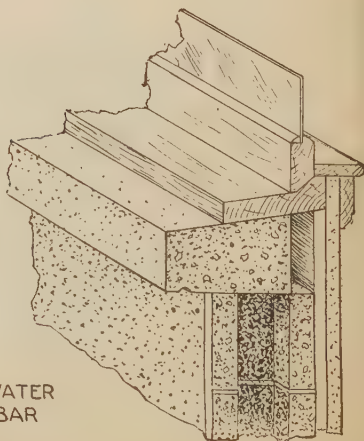
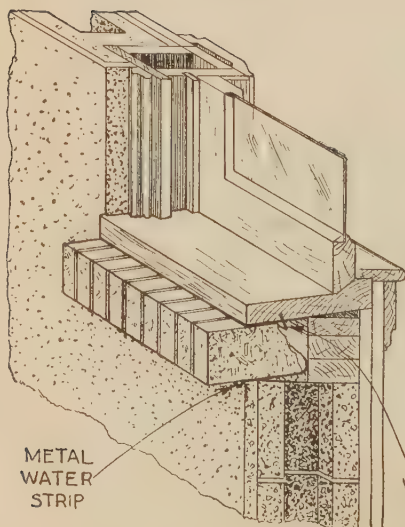
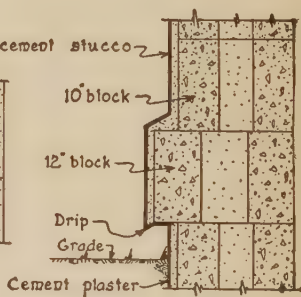
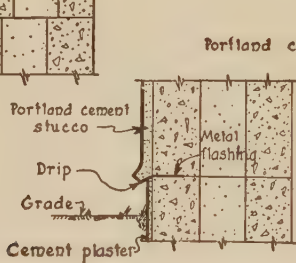
FIG. 5,255.—Dimensions of openings for several sizes of windows using 8×8×16 blocks.



FIG. 5,256.—A precast sill to fit in with the block course. The dotted white lines indicate the ends of the sill made the same height as the block course.



FIGS. 5,257 to 5,259.—Grade courses.



FIGS. 5,260 and 5,261.—Common types of sill.

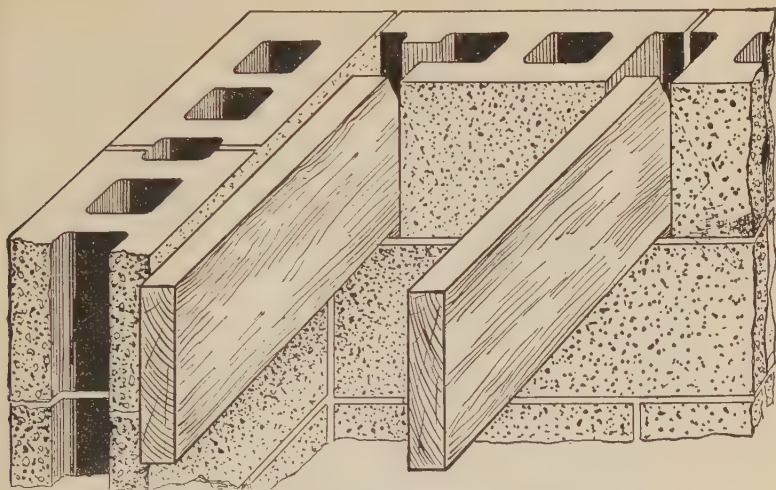


FIG. 5,262.—Joist block as used in hollow block wall construction. }

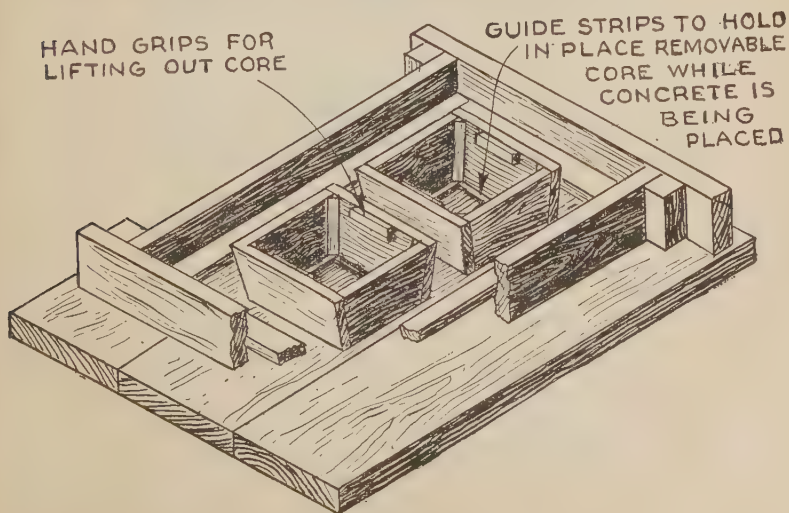


FIG. 5,263.—Form for making hollow blocks showing cores.

Joist Blocks.—A feature of great convenience in concrete block construction is the special joist block having a recess allowing a footing in the wall for the support of joists as shown in fig. 5,262. In the figure note the corner special and the intermediate special. Underwriters demand a “fire cut” on the end of joists built into the wall so that in case of fire causing the collapse of a wood floor, the joists can fall out of the wall without endangering the stability of the latter.

Cleaning the Wall.—After completion of the wall it should be scrubbed with a stiff fibre or wire brush and water, if it has been soiled or stained during construction. Divers stains may require a scrubbing with a solution of muriatic acid varying in strength from about one part acid in three parts water to one part acid in eight parts water. The solution should be allowed to remain on the surface until it stops bubbling. It should then be removed by thoroughly washing with clean water.

CHAPTER 93

Waterproofing

The peculiar structure and formation of concrete is responsible for its ready absorption of water. A block of concrete set in a pan of water as shown in fig. 5,264, with 4 or 5

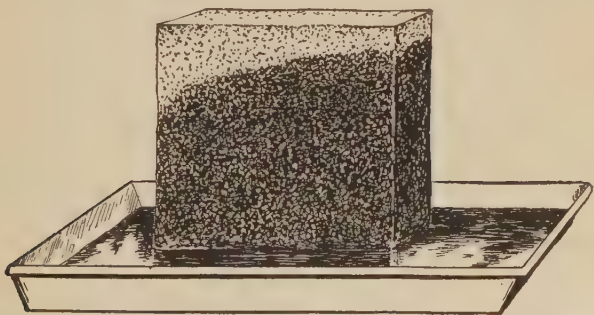


FIG. 5,264.—Experiment showing that concrete is porous. A concrete wall will absorb moisture exactly as this concrete block has absorbed water, as indicated by the darkened section.

ins. of its upper section entirely clear of the liquid will in a short time absorb a considerable volume of water. This absorption is by no means confined to that section of the concrete immersed in the water but becomes apparent even in that section of the concrete above the water level. The water rises with the structure of the concrete just as it would rise in a wick, except that it takes a little more time.

The same absorption of water applies to a concrete wall or floor—the concrete will absorb or drink up the moisture directly out of the ground. Where the soil moisture is comparatively slight, there is a correspondingly small amount of absorption, with the result of an apparently dry basement. But when this moisture increases as a consequence of rains or other physical conditions, dampness or seepage immediately make themselves apparent.

However, seepage, or the actual appearance of wetness are not always necessary as visible evidence of a damp structure. For instance, a cement basement may be very damp without showing any evidence of water at all. This is especially true if the basement be well ventilated—the moisture then evaporates so rapidly as to leave no wet effect. The reason concrete is porous is because in its making, water is necessary to cause the chemical action to take place necessary for the hardening of the mixture. This hardening takes place while the water is still present.

Now during the process of hardening there is no perceptible shrinkage hence all the water remaining in the cement, about 30% must evaporate while the cement is drying out. As the volume of cement does not shrink there is left as many minute voids as would contain the water. Thus its porous nature and the need of waterproofing.

Waterproofing Roofs.—Where concrete roofs are made flat in order to provide a flat ceiling without the use of a suspended ceiling, or when a future floor is used as a temporary roof, some construction must be placed on the concrete slab to provide for drainage.

A cinder fill placed on the roof in such a manner as to drain it properly is most commonly used for this work. Such construction has not in all cases given satisfactory results, but if a little care be exercised in selecting and grading cinders to be used for such work and also in placing them, good results will be obtained.

The cinders used for a cinder fill should be of a porous grade of screened steam boiler cinders, free from refuse or slag, which only add unnecessary weight to the fill. Cinders mixed with fire brick, unburned coke, slag and similar refuse should not be used, since the prime advantage of cinders as a fill is their relative light weight, and if this rule is not obeyed crushed stone might as well be used.

The cinders should be wet down thoroughly, then placed on the roof and arranged to form the proper slopes and tamped to an even surface, a little more water being sprayed upon the surface if necessary, to compact them thoroughly. The minimum thickness in any place should not be less than 3 ins. to obtain good results.

After a portion of the roof has been covered with cinders, as prescribed above, and before they have dried out entirely, a mortar coating about 1 in. thick, composed of 1 part cement and 3 parts clean sand, mixed quite wet, should be placed on

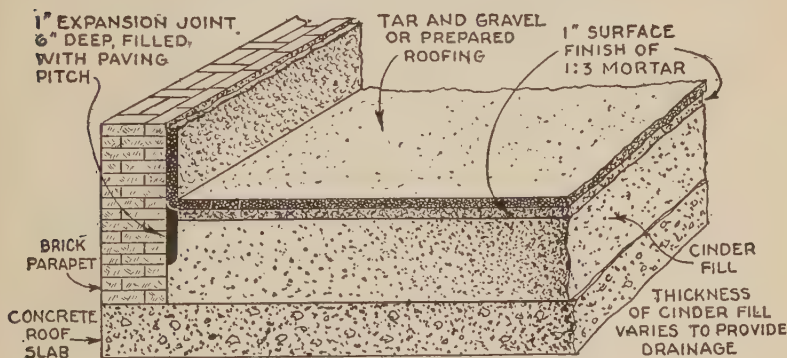


FIG. 5,265.—Cinder fill on concrete roof slab for drainage.

the cinders and given a smooth float finish. The mortar being mixed wet, some of it will seep into the cinders and as a result its top surface becomes a cinder concrete, making the total thickness of the mortar coat somewhat more than 1 in. After the mortar has thoroughly set the roofing should be applied.

When placing the top portion of the cinder fill and the mortar finish it should be kept an inch or two from all parapet walls to provide for expansion; this space to be filled with

some bituminous or asphalt paving pitch which becomes soft under the sun and very readily allows for expansion.

Fig. 5,265, shows a concrete roof with cinder fill for drainage. While placing and tamping the cinders, 1 in. or 2 in. boards side by side can be placed against all walls and parapets, extending into the fill for a few inches and the cement mortar coat placed against them. After the mortar has set the boards should be removed and pitch should be poured into the joint.

The weight of cinder fill construction as here described, will vary from 65 lbs. to 75 lbs. per sq. ft. for a depth of 1 ft., depending upon the grade of cinders used. The actual weight of fill at various points on the roof will, however, vary considerably on account of the slopes. If downspouts be properly located, the average depth of fill required should be but little over 12 ins. thus allowing for a maximum depth of 21 ins. and a minimum of 3 ins. At a slope of $\frac{3}{8}$ in. per ft. this depth would be sufficient to provide for drainage 48 ft. each way from the downspout. To have much more area than this tributary to one downspout cannot be considered good design, since there is too much danger of serious trouble should the downspout become clogged.

It should be borne in mind that it is cheaper to supply more downspouts than to overload the roof slab with cinders to care for the deficiency. When too great a depth of cinders is used the concrete roof, which must be designed to carry the load, will be unnecessarily heavy and costly, and consequently uneconomical.

It should be remembered when designing concrete roofs which are to carry cinder fills that it is highly important that the weight of fill and roofing be taken into account in the calculations.

Waterproofing Foundations.—The amount of dampness or capillary water to be overcome has much to do with the degree to which waterproofing must be done. It often develops in foundations already erected that provision has not been made

NOTE.—*Waterproofing a concrete roof.* This has been successfully accomplished by the use of a $\frac{1}{2}$ in. coating of mortar in the proportion of one to two, applied before the concrete had set and troweled smooth. A solution of 1 lb. of concentrated lye and 5 lb. of alum was made up with 2 gal. of water, and used by diluting one part of it with 30 parts of water. A mixture of 2 lb. of cement in a pint of this diluted solution is applied in two coats to the fresh mortar. A large reinforced concrete pipe was also waterproofed in much the same manner and has likewise remained tight for several years.

for keeping out water, and a means must be found to overcome the trouble without excavating around them. Not only is it expensive but defaces the grounds and loosens the earth that formerly was settled and compact.

If only enough dampness penetrate the wall to show wet, the walls may be made waterproof by treating them inside with one of several liquid damp proof preparations; the same remedy will apply to the floor.

WRONG WAY



RIGHT WAY



FIGS. 5,266 and 5,267.—Right and wrong way to drain rain water from foundation walls by means of strip of concrete. Note that the concrete should extend up to the walls as in fig. 5,267.

Where a greater amount of dampness comes through, it may be due to lack of surface drainage around the building.

In such case, the trouble may be overcome by laying a strip of concrete with a fall projecting from the walls as in fig. 5,267, and not as in fig. 5,266. In new construction where the conditions are such that water will reach the foundation before settling providing for drainage outside and adjacent to the foundation walls should be provided as in fig. 5,268. As shown there is a tile drain laid around outside the foundation below the cellar floor with a fall in the direction of most or least seepage earth. By being filled in with sand, gravel, slag or stones the water quickly settles away without penetrating the wall. Instead of this provision the wall could have been waterproofed with a coat of asphaltum, tar or pitch on the outside, worked thoroughly into the mortar joints or given a coat of cement grout $\frac{3}{16}$ in. thick brushed in or put on with a trowel.

Figs. 5,269 and 5,270 show method of relieving water pressure on cellar floors and walls.

For dwellings and buildings where the water pressure is under six or seven feet, it is usual to put in the footings for the walls 12 ins. wider on

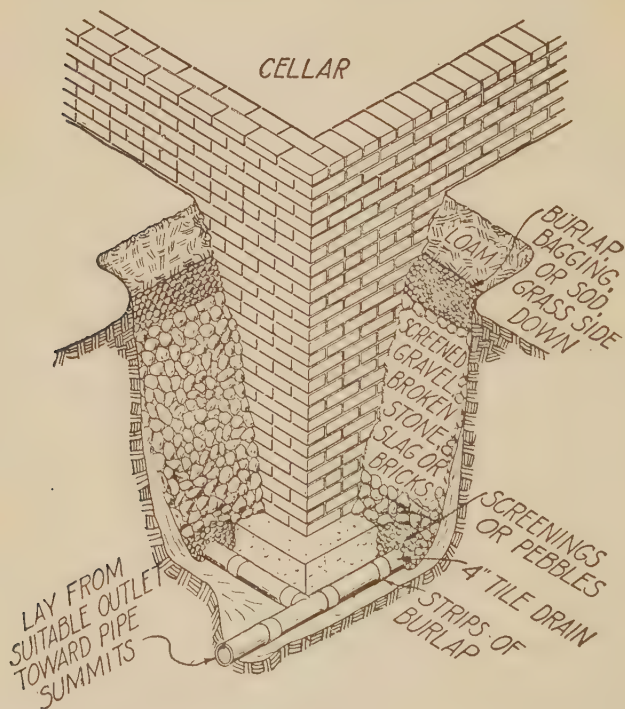
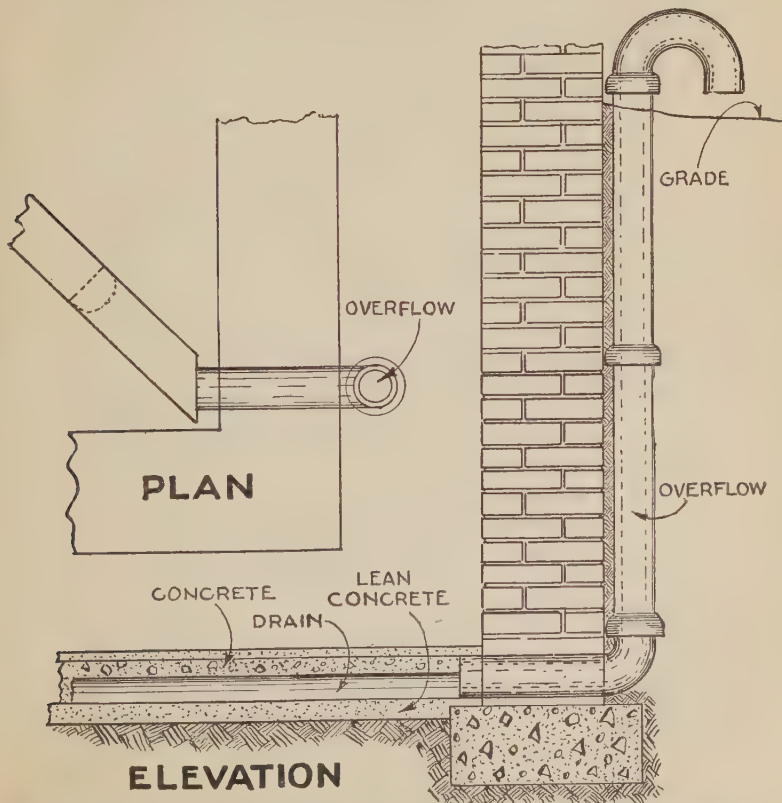


FIG. 5,268. —External drainage to carry off water which does not settle outside of foundation.

the inside than the walls and lay wall on the outside edge of the footing up to a point about three feet above the permanent water level in the ground and put a *down key* 3 ins. deep and 8 ins. or 12 ins. wide in the footings to prevent the main part of wall sliding inward when built on membrane waterproofing, as all waterproofing is more or less a lubricant.

A *down key* centers the wall bearing; an upward key tends to split the wall. Then put on the membrane waterproofing across the footings and up the inside of the 4 in. wall to the height required, and build the walls of the building. After the walls are built, carry the waterproofing over the cellar floor, connecting it with the lap of the waterproofing under the walls, making one membrane of cellar floor and walls to height required. Where there are pits or trenches, the waterproofing is carried down into the pit and over the bottom and connected to the waterproofing membrane in the floor



FIGS. 5,269 and 5,270.—Plan and elevation of cellar construction below tide and spring water showing tile relief drain pipes to relieve the pressure due to head of water.

and protected with masonry. Where there are interior columns, the waterproofing is carried underneath the column footings, if the pressure be not too great; 60 lbs. per sq. in. is the limit of load.

If the pressure be too great for the membrane to withstand, a sheet of heavy copper is put under the column and connected to the waterproofing of the floor, or the membrane can be carried up around the columns or piers and protected with masonry or metal casing.

When there is a greater pressure of water than 6 or 7 ft. it is the general practice not to put in a pressure cellar if the area be large, on account of

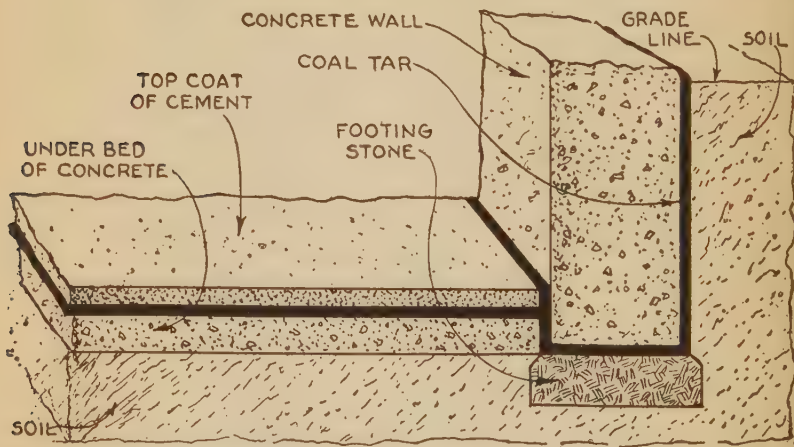


FIG. 5,271.—Coal tar membrane water-proofing. By this system other materials are successfully used, some of them, such as petroleum asphaltums are applied without the membrane, in some instances claiming superiority over pitch because they will not crack.

the thick floor required and large expense. As a matter of fact, it is practicable to resist almost any pressure by the membrane method if the structure can be temporarily pumped dry and expense is not objected to.

There are a few instances of pressures due to 30 or 40 ft. head being successfully resisted where the area is small. The usual method of waterproofing where there is great pressure, is, as shown in fig. 5,272, to build the building with as good concrete

walls as possible, using the best method of integral waterproofing for the concrete, and then lining them on the inside with a drainage course of 3 in. hollow, vitrified tile carried down to a point below the floor slab.

The floor of the cellar is then covered on the earth with a 2 in. bed of concrete as a filter course and a drainage course of broken stone, about 8 ins. thick, put over the bottom and carried against the hollow tile on walls to receive any seepage through the walls, which are covered with 2 in. concrete smoothed off ready to receive the membrane waterproofing. This is put over the floor and up on the 3 in. tiled walls and up around all piers and columns and into all pits and trenches and protected with concrete and brick work.

Waterproofing Membranes.—For a number of years burlap has been extensively used as a membrane or medium for holding or surfacing the waterproofing material. It has been found that burlap is objectionable for the purpose because it will not take the saturation; it will blacken on the outside, but remains unsaturated on the inside of the fibre, chemical action continues, and in a few years the fibre has lost all strength, becoming just a pulp.

Another membrane for waterproofing that has been on the market for some years seems to be free from the defects of the previous ones. This one is a strong coarse weave of cotton cloth, which has great tensile strength, saturates perfectly and has the good quality of permitting the asphaltum or pitch to pass freely through the sheet, thereby firmly bonding the newly applied sheet to the previous one.

This is a great improvement over any saturated felt. Whether it is of value enough to warrant the greatly increased cost is a question. The old saturated felts have proved, when properly applied, to have a life of half a century or more, which is certainly a pretty fair record.

One of the most persistent abuses in the waterproofing of roofs is the employment of *exposed* membrane waterproofing,

especially for flashings of walls and openings and for the covering of bulkheads and backs and tops of cornices. It is very

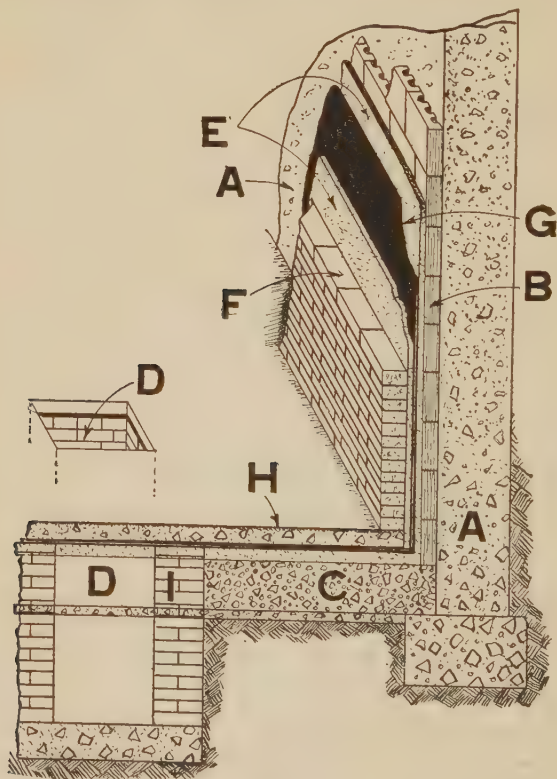


FIG. 5,272.—Interior water-proofing for heavy pressure cellar. As may be clearly seen, any moisture coming through the foundation A, must follow the hollow tile B, into the broken stone course C, and thence into the sump D, which is built to receive the seepage of the walls and bottom is put below the stone drainage level and automatic pumps in duplicate are installed to pump the seepage overboard. This construction is giving perfect water and damp-proof cellars in a great number of modern buildings. The pits and trenches are waterproofed as pressure below the drainage course level. E, is the cement coat inside and outside of G, the brick wall lining backing the inside cement coat against the water proofing. F, is the brick wall lining backing the inside cement coat against the water proofing. H, finish floor; I, porous brick part open joints for seepage. These brick and brick F, may be hollow.

difficult to make any bituminous waterproofing last a reasonable time. The only virtue of this practice is cheapness, a temporary saving.

Membrane waterproofing built into masonry walls and protected thereby, is a good substitute for copper flashing and may last as long, but any black roof, of rock asphalt or any kind of membrane unprotected on a permanent building is objectionable.

Integral Compounds.—Many of the proprietary preparations commonly referred to as integral compounds are of questionable composition and none of them has been in use long enough as yet for one to say positively that the results obtained by their use will be permanent or that the composition of some of them is such as not to be injurious to the concrete.

Some of the earliest experiments toward increasing the water tightness of concrete consisted of adding a small amount of clay to the other materials. But as any quantity of clay over a very small percentage affects the strength of concrete and as it is not possible to add clay out on the job in the same manner that it is added when making laboratory experiments, such a practice is questionable.

Hydrated lime, often added to concrete mixtures, acts only as a void filler. The danger in it is that too much lime may be used, affecting the strength of the concrete. A little more cement instead of lime would serve the purpose without the same danger.

The use of integral compounds is apt to encourage careless proportioning and placing, with the idea that the use of the additional materials or compounds will make good the lack of carefulness.

Some Commonly Used Methods.—Integral compounds that are not in the nature of void fillers combine with free chemical salts in the concrete to form insoluble compounds. Such preparations frequently contain sodium silicate, commonly known as water glass. In fact, such a preparation is useful when porous concrete must be treated to make it watertight.

One part of the chemical dissolved in 3, 4 or 5 parts of water and applied as a paint at intervals of 24 hours will eventually fill the pores and render the surface watertight. Usually two or more applications are required, depending upon the porosity of the concrete. Another treatment known as Sylvester's treatment, which consists of separate soap and alum solutions, acts in a similar manner.

A formula that has been used generally is the following:

Dissolve five pounds of powdered alum and one pound of lye in ten quarts of water. Use $\frac{1}{2}$ pint of this mixture in every bucketful of water used in mixing the cement. For an outside waterproof wash, add $\frac{1}{2}$ pint of this mixture to a bucket of water and thicken to a heavy wash with pure cement.

Result of Rapid Drying Out.—Even though concrete may have been properly proportioned, mixed and placed, the mass may be porous as a result of allowing it to dry out too rapidly. The remedy is to leave forms in place and protect it against too rapid drying out. If suitable protection be not afforded the concrete instead of hardening, simply dries out as a result of evaporation of a large portion of the mixing water.

Cement construction which exposes a large surface area to sun and wind, such as walks, feeding floors, barnyard pavements, etc., must be protected against rapid drying out by a layer of some moisture retaining material.

NOTE.—According to the Bureau of Standards: "The addition of so-called waterproofing compounds will not compensate for lean mixtures, nor for poor materials, nor for poor workmanship in the fabrication of concrete, since, in practice, the inert integral compounds (acting simply as void filling material) are added in such small quantities they have very little or no effect on the permeability of the concrete. If the same care be taken in making the concrete impermeable without the addition of waterproofing, as is ordinarily taken when waterproofing materials are added, an impermeable concrete can be obtained. In order to obtain such impermeable mortar or concrete considerable care should be exercised in selecting good materials as aggregates and proportioning them in such a manner as to obtain a dense mixture. The consistency of the mixture should be wet enough so that it can be puddled, the particles flowing into position without tamping. The mixture should be well spaded in the forms when placed so as to avoid the formation of pockets on the surface."

Sand, sawdust, hay, straw, old canvas, burlap, carpets, or similar covering applied as soon as the concrete surface can be covered without marring it, accomplishes the purpose. Such coverings should be kept wet by frequent sprinkling for from a week to ten days or more, depending upon the nature of the work and the temperature conditions. Manure may be used for this purpose only if means be provided for preventing manure



FIGS. 5,273 and 5,274.—Damp proofing the outside of a cellar wall. Fig. 5,273 shows the application of a penetrating, bituminous, priming and bonding coat cold with a brush. After the primer is set and dry, a bituminous compound is melted in large kettles and is swabbed on hot with a roofing mop as shown in fig. 5,274. The coating should be thick, tough, and somewhat elastic and yielding.

coming into direct contact with the fresh concrete and spoiling its appearance.

Damp Proofing.—In some instances the moisture seepage is very slight or just enough to make the interior surface of the

walls damp. Some think they can overcome this by applying furring strips, lathing and plastering. Although the surface appears dry, there is the same trouble back of it which eventually rots the furring and lath.

There are numerous damp proofing compounds, some giving satisfactory results. One preparation consists of linseed oil and plaster of Paris, prepared by adding the plaster of Paris to the oil until a paste is formed, not too thin.

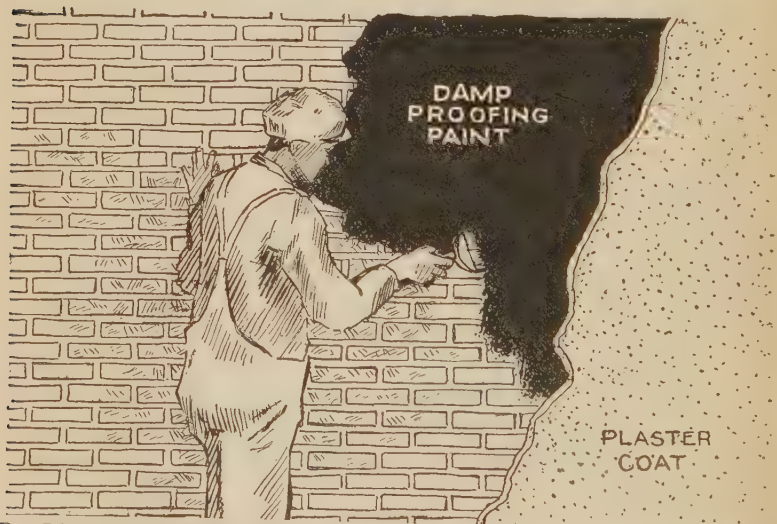


FIG. 5,275.—Damp proofing point and plaster coat. The illustration shows the application of a heavy, penetrating, tacky, bonding and damp-proofing paint to a brick wall. The plaster coat is troweled directly on the painted surface, thus protecting the paint and preventing flaking and peeling.

If the surface be smooth enough it may be brushed on and rubbed over and into the surface until there is none left on the outside. It will become very tough and hard but not brittle when finally set, leaving an impervious and smooth finish. Figs. 5,273 to 5,275 show methods of damp proofing.

CHAPTER 94

How to Figure Concrete Work

Estimating the cost of a concrete building is somewhat simpler than figuring for brick construction so far as determining the amount of material required. However, an additional calculation must be made for the forms. The calculation involves finding

1. The volume to be filled with concrete.
2. Quantity of materials.
3. Lumber for forms.
4. Labor.

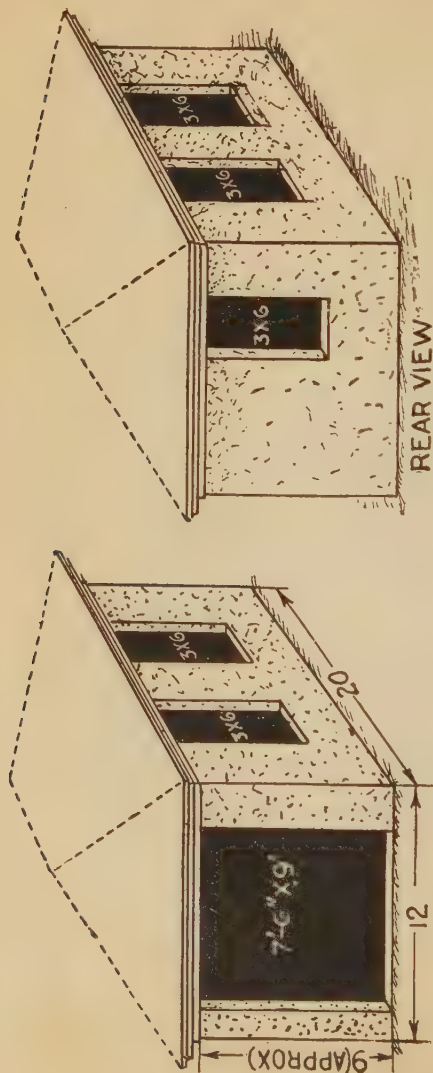
Of course, to figure the cost of the complete building there must be added to the estimate of above items the cost of the windows, doors, roof, hardware, etc., which has already been explained.

Example —Estimate the quantity of concrete required for the small garage shown in figs. 5,276 to 5,280.

First estimate the cost of materials, then the cost of labor.

1. Cost of Materials

Foundation and Floor.—Calculated cu. yds. of concrete



FIGS. 5,276 and 5,277.—Front and rear view of 12x30 garage with 8 in. concrete walls.

from plan and cross section of foundation and floor, figs. 5,278 and 5,279 thus:

$$\text{Section } A+B = \left\{ \left(\frac{6}{12} \times \frac{12}{12} \right) + \left(\frac{12}{12} \times \frac{8}{12} \right) \right\} \times \left\{ (2 \times 20) + (2 \times 10\frac{2}{3}) \right\} \dots = 71.5 \text{ cu. ft.}$$

$$\text{Section } C = \left(\frac{9}{12} \times 10\frac{2}{3} \right) \times 20 \dots \dots \dots = 160 \text{ cu. ft.}$$

$$\text{Approach (fig. 5,286)} = \frac{9}{12} \left(\frac{8+10}{2} \times 6 \right) \dots \dots \dots = 40.5 \quad "$$

$$\text{Total volume of concrete} \dots \dots \dots = 272 \quad "$$

Weights of Floors, Roof and Walls

KIND	Weight in Lbs. per Sq. Ft.
FLOORS	
7/8 in. Maple finish floor and 7/8 in. spruce under floor on 2 in. x 4 in. sleepers, 16 in. centers, with 2 in. dry cinder concrete filling.....	18 lbs.
Cinder concrete filling per inch of thickness.....	7
Cement finish per inch of thickness.....	12
Asphalt mastic flooring 1 1/2 in. thick.....	18
3 in. Creosoted wood blocks on 1/2 in. mortar base.....	21
Solid flat tile on 1 in. mortar bed.....	23
CEILINGS	
Plaster on tile or concrete.....	5
Suspended Metal Lath and plaster.....	10
ROOFS	
Five-ply felt and gravel.....	6
Four-ply felt and gravel.....	5 1/2
Three-ply ready roofing.....	1
Cement tile.....	16
Slate, 1/4 in. thick.....	9 1/2
Sheathing, 1 in. thick, Yellow Pine.....	4
2 in. Book Tile.....	12
3 in. Book Tile.....	20
Skylight with galvanized iron frame, 3/4 in. glass.....	6

KIND	Weight in Lbs. per Sq. Ft.		
	Unplastered.	One Side Plastered.	Both Sides Plastered.
WALLS			
9 in. Brick Wall.....	84	89	..
13 in. Brick Wall.....	121	126	..
18 in. Brick Wall.....	168	173	..
22 in. Brick Wall.....	205	210	..
26 in. Brick Wall.....	243	248	..
4 in. Brick, 4 in. Tile Backing.....	60	65	..
4 in. Brick, 8 in. Tile Backing.....	75	80	..
9 in. Brick, 4 in. Tile Backing.....	102	107	..
8 in. Tile.....	33	38	43
12 in. Tile.....	45	50	55
PARTITIONS			
3 in. Clay Tile.....	17	22	27
4 in. Clay Tile.....	18	23	28
6 in. Clay Tile.....	25	30	35
8 in. Clay Tile.....	31	36	41
10 in. Clay Tile.....	35	40	45
3 in. Gypsum Block.....	10	15	20
4 in. Gypsum Block.....	12	17	22
5 in. Gypsum Block.....	14	19	24
6 in. Gypsum Block.....	16	21	26
2 in. Solid Plaster.....	..	..	32
4 in. Solid Plaster.....	..	..	32
4 in. Hollow Plaster.....	..	..	22

*From "Useful Data," a handbook published by the Corrugated Bar Company, Buffalo, N.Y.



FIG. 5,278.—Plan of garage.

Bearing Power of Soils in Tons per Square Foot

	Minimum	Maximum
Rock, hardest.....	200	..
Rock equal to best ashlar masonry.....	25	30
Rock equal to best brick masonry.....	15	20
Rock equal to poor brick masonry.....	5	10
Clay, thick beds, always dry.....	6	8
Clay, thick beds, moderately dry.....	4	6
Clay, soft.....	1	2
Gravel and coarse sand, hard.....	8	10
Sand, dry, well packed.....	4	6
Sand, clean, dry.....	2	4

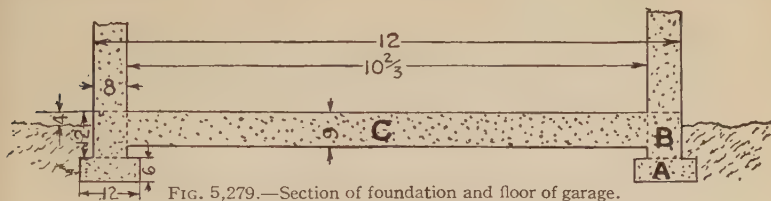


FIG. 5,279.—Section of foundation and floor of garage.

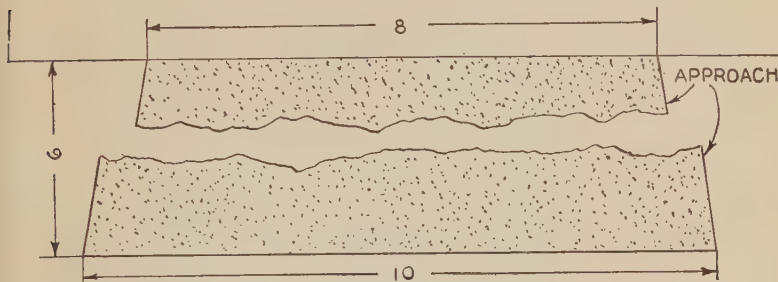


FIG. 5,280.—Approach to garage.

NOTE.—Summary of time required to mix and deposit concrete by hand. Where the concrete is mixed by hand with only one mixing board being used, and in instances where the concrete is shoveled directly from the mixing board into the forms or trenches, it will require from $3\frac{1}{4}$ to $3\frac{1}{2}$ hrs. labor time for one man to mix and deposit one cu. yd. of concrete. If it should be necessary to load the concrete into barrows and wheel same to point of deposit, it will require 4 to $4\frac{1}{2}$ hrs. time for one man to mix and deposit one cu. yd. of concrete. During extremely hot weather or in tropical climates where the men are unable to perform as much work per day as in cooler climates, it will require from 4 to $4\frac{1}{2}$ hrs. time for one man to mix and deposit one cu. yd. of concrete where it is possible to shovel same from the mixing board directly into forms or trenches. If it be necessary to load the concrete into barrows and wheel same from mixing board to point of deposit, it will require from $4\frac{3}{4}$ to 5 hrs. time for one man to mix, wheel and deposit one cu. yd. of concrete. The above apply to instances where only one mixing board is being used. Where the concrete is mixed by hand, where there are two mixing boards being used so that the men handling material are able to work to better advantage, and where it is possible to shovel the concrete from the mixing boards directly into the forms or trenches, it will require $2\frac{1}{2}$ to 3 hrs. labor time to mix and deposit one cu. yd. of concrete. If it should be necessary to load the concrete into barrows and wheel same from the mixing board to point of deposit, it will require from $3\frac{1}{2}$ to $3\frac{3}{4}$ hrs. time for one man to mix, wheel and deposit one cu. yd. of concrete. During very hot weather and in warm climates where the men are unable to work either as fast or as steady as in the cooler localities, it will require from $3\frac{1}{2}$ to $3\frac{3}{4}$ hrs. for one man to mix and deposit one cu. yd. of concrete where two mixing boards are being used where it is possible to shovel the concrete from the mixing boards directly into the forms or trenches. If it should be necessary to load the concrete into barrows and wheel same from the mixing board to place of deposit, it will require from $4\frac{1}{4}$ to $4\frac{1}{2}$ hrs. time for one man to mix, wheel and deposit one cu. yd. of concrete.—Walker.

Walls.—To determine the quantity of concrete required for the walls, calculate gross volume of sides, that is assuming no

Building Code Requirements for Live Load

In Pounds Per Square Foot

STRUCTURE	Baltimore	Boston	Buffalo	Chicago	Cincinnati	Indianapolis	Milwaukee	Minneapolis	New Orleans	New York	Philadelphia	Pittsburgh	St. Louis	San Francisco	Seattle	Washington
Apartments.....	60	50	70	40	40	50	30	50	40	...	70	...	50	60	40	50
Assembly Halls.....	...	...	100	100	100	125	...	125	...	100	120	150	100	...	...	...
Dwellings.....	60	50	40	40	40	50	30	50	40	40	70	70	50	60	40	50
Hospitals.....	...	...	70	50	...	50	30	50	...	...	70	...	50	60	50	...
Hotels.....	60	...	70	50	40	75	30	50	40	...	70	...	50	60	40	50
Manufacturing.....	175	...	...	...	150	200	...	...	...	...	150	200	150	250	...	...
Light Manufacturing.....	125	125	120	100	100	100	100	100	125	...	120	...	100	125	125	...
Heavy Storehouses.....	250	250	...	...	150	200	...	...	...	...	150	...	...	250	...	150
Warehouses.....	...	250	150	...	150	200	...	...	200	...	150	200	150	250	...	150
Offices.....	75	100	70	50	50	75	40	75	70	60	100	...	60	60	50	75
Schools—Class Rooms.....	75	60	...	...	60	100	40	100	60	75	...	...	75	75	50	75
Stairways, General.....	...	70	...	100	80	...	60	...	70	...	...	...	...	...	100	...
Roofs—Slope Under 20°.....	...	40	40	25	25	30	30	50	30	40	30	50	30	30	40	25
Wind Pressure.....	30	...	30	20	20	...	30	30	...	30	30	...	30	20	...	30

doors or windows and then deduct volume of openings for doors and windows. Thus:

$$\text{Gross volume of sides} = 2 \left(20 \times 9 \times \frac{8}{12} \right) + 2 \left(10\frac{2}{3} \times 9 \times \frac{8}{12} \right) = 368 \text{ cu. ft.}$$

For Determining Materials Required for Small Quantities of Concrete

Cubic feet of Concrete	1: 1 1/2: 3 Mixture			1: 2: 3 Mixture			1: 2: 4 Mixture			1: 2 1/2: 5 Mixture			1: 3: 6 Mixture		
	Bags Cement	Cu. Ft. Sand	Cu. Ft. Stone	Bags Cement	Cu. Ft. Sand	Cu. Ft. Stone	Bags Cement	Cu. Ft. Sand	Cu. Ft. Stone	Bags Cement	Cu. Ft. Sand	Cu. Ft. Stone	Bags Cement	Cu. Ft. Sand	Cu. Ft. Stone
100	28	42	84	25%	51%	77%	22	44	88	18	45	90	16	48	96
90	25%	37%	75%	23%	46%	69%	19%	39%	79%	16%	40%	81	14%	43%	86%
80	22%	33%	67%	20%	41%	62	17%	35%	70%	14%	36	72	12%	38%	76%
70	19%	29%	58%	18	36	54	15%	30%	61%	12%	31 1/2	63	11%	33%	67%
60	16%	25%	50%	15 1/2	31	46 1/2	13%	26%	52%	10%	27	54	9%	28%	57%
50	14	21	42	13	26	39	11	22	44	9	22 1/2	45	8	24	48
40	11 1/2	16%	33%	10%	20%	31	8%	17%	35%	7 1/2	18	36	6%	19%	38%
30	8%	12%	25%	7 1/2	15 1/2	23 1/2	6%	13%	26%	5%	13 1/2	27	4%	14%	28%
20	5%	8%	16%	5%	10%	15%	4%	8%	17%	3%	9	18	3%	9%	19%
10	2%	4%	8%	2%	5%	7%	2%	4%	8%	1%	4 1/2	9	1%	4%	9%
9	2 1/2	3%	7%	2 1/2	4%	7	2	4	8	1 1/2	4	8	1 1/2	4%	8%
8	2 1/4	3 3/8	6 3/4	2	4%	6 1/2	1 3/4	3 1/2	7	1%	3%	7 1/2	1 1/4	3 1/2	7 1/4
7	2	3	6	1%	3 1/2	5%	1 1/2	3	6	1 1/4	3%	6 1/4	1 1/8	3%	6%
6	1%	2 1/2	5	1%	3%	4%	1 1/4	2%	5 1/4	1 1/10	2 1/4	5 1/2	1	3	6
5	1%	2 1/10	4%	1%	2%	4	1 1/10	2%	4%	1%	2 1/4	4%	1%	2%	4%
4	1 1/4	1 3/4	3%	1	2	3 1/2	1 1/4	3%	3 1/2	1 1/10	1%	3%	1%	2	4
3	1%	1 1/4	2 1/2	3/4	1 1/2	2 1/4	3/4	1 1/4	2%	1/2	1 1/2	2%	1/2	1 1/2	3
2	1/16	3/8	1 1/16	1/2	1	1 1/2	1/6	3/8	1%	1/3	1 1/3	1%	1/16	1	2
1	1/32	1/16	1/8	1/4	1/2	3/4	1/32	1/16	1/8	1/6	1/2	1	1/32	1/2	1

*Example:—*To find the materials for 291 cubic feet of 1:2:4 mixture, look in the columns headed "1:2:4 mixture," copy out the figures for 100 cubic feet and multiply them by two, to make 200. This gives 44 bags cement, 88 cubic feet of sand, and 176 of stone. Then look under the same head, opposite 90 cubic feet; 19 1/2 bags cement, 39 3/4 cubic feet sand, and 79 1/2 cubic feet stone. Then look opposite 1 cubic foot and there is found 1/32 bag cement, 1/16 cubic foot sand, and 1/8 cubic foot stone. Add these three, and it will be found that for 291 cubic feet of concrete in 1:2:4 mixture, there will be needed 64 bags cement, 128 cubic feet sand, and 256 cubic feet stone or gravel.

*Table of Proportions and Quantities for One Cubic Yard of Concrete using various sizes of aggregates

Based upon laboratory investigations, using approved materials, compressive strength, 28 days, with workable plasticity, 6 by 12-inch cylinders, 3,000 pounds per square inch.

Sizes		Fine Aggregates, Screen Openings per Inch														
Coarse Aggregates Inches	Cement in bbls. Aggregates in Cubic Yards	0-28			0-14			0-8			0-4			0-3/8-in.		
		Cement	Fine	Coarse	Cement	Fine	Coarse	Cement	Fine	Coarse	Cement	Fine	Coarse	Cement	Fine	Coarse
No. 4 Screen to 3/4	Proportions....	1	1.3	2.4	1	1.6	2.4	1	1.8	2.3	1	2.0	2.3	1	2.7	1.5
	Quantities....	1.96	.37	.69	1.85	.44	.66	1.82	.48	.62	1.75	.52	.59	1.79	.72	.40
No. 4 Screen to 1	Proportions....	1	1.3	2.7	1	1.6	2.6	1	1.8	2.6	1	2.0	2.5	1	2.6	1.8
	Quantities....	1.90	.36	.76	1.77	.42	.68	1.72	.46	.66	1.67	.50	.62	1.72	.66	.46
No. 4 Screen to 1 1/2	Proportions..	1	1.2	3.1	1	1.6	3.2	1	1.7	3.1	1	2	3	1	2.4	2.4
	Quantities...	1.82	.32	.84	1.68	.40	.79	1.63	.41	.75	1.61	.47	.72	1.62	.57	.57
3/8 to 3/4	Proportions.	1	1.3	2.3	1	1.7	2.3	1	1.9	2.3	1	2.2	2.2	1	2.8	1.4
	Quantities.	1.96	.37	.67	1.85	.46	.63	1.82	.51	.62	1.75	.57	.57	1.79	.75	.37
3/8 to 1	Proportions...	1	1.3	2.6	1	1.7	2.6	1	1.9	2.5	1	2.2	2.4	1	2.7	1.7
	Quantities	1.90	.36	.74	1.77	.44	.68	1.72	.48	.64	1.67	.54	.59	1.72	.68	.43
3/8 to 1 1/2	Proportions..	1	1.3	3.0	1	1.7	3.0	1	1.9	3.0	1	2.1	2.9	1	2.6	2.2
	Quantities...	1.82	.35	.80	1.68	.43	.75	1.63	.46	.73	1.61	.50	.68	1.62	.63	.53
1/2 to 3/4	Proportions..	1	1.5	2.3	1	1.9	2.2	1	2.1	2.2	1	2.3	2.1	1	2.8	1.3
	Quantities	1.96	.44	.67	1.85	.52	.61	1.82	.56	.59	1.75	.59	.54	1.79	.75	.34
1/2 to 1	Proportions..	1	1.5	2.5	1	1.9	2.5	1	2.1	2.4	1	2.3	2.4	1	2.8	1.6
	Quantities..	1.90	.42	.70	1.77	.50	.66	1.72	.53	.61	1.67	.57	.59	1.72	.72	.41
1/2 to 1 1/2	Proportions..	1	1.4	2.8	1	1.9	2.9	1	2.1	2.9	1	2.2	2.8	1	2.7	2.1
	Quantities.	1.82	.37	.75	1.68	.47	.73	1.63	.51	.69	1.61	.52	.66	1.62	.65	.51
1/2 to 2	Proportions.	1	1.4	3.3	1	1.9	3.3	1	2.0	3.4	1	2.2	3.3	1	2.7	2.7
	Quantities...	1.75	.36	.86	1.63	.46	.79	1.55	.46	.78	1.52	.50	.74	1.53	.62	.62
3/4 to 1	Proportions..	1	1.7	2.4	1	2.1	2.4	1	2.4	2.1	1	2.6	2.2	1	3.1	1.5
	Quantities...	1.90	.48	.68	1.77	.55	.63	1.72	.61	.53	1.67	.64	.55	1.72	.79	.39
3/4 to 1 1/2	Proportions..	1	1.7	2.7	1	2.0	2.8	1	2.3	2.7	1	2.5	2.7	1	3.0	2.0
	Quantities.	1.82	.46	.73	1.79	.50	.70	1.63	.55	.65	1.61	.59	.64	1.62	.73	.48
3/4 to 2	Proportions....	1	1.7	3.1	1	2.0	3.1	1	2.3	3.1	1	2.5	3.0	1	3.0	2.4
	Quantities.	1.75	.44	.80	1.63	.48	.75	1.55	.53	.72	1.52	.56	.67	1.53	.68	.55
1 to 1 1/2	Proportions....	1	1.7	2.8	1	2.0	2.9	1	2.3	2.7	1	2.6	2.6	1	3.1	2.0
	Quantities..	1.82	.46	.75	1.68	.50	.73	1.63	.55	.65	1.61	.62	.62	1.62	.75	.48
1 to 2	Proportions..	1	1.5	3.2	1	1.9	3.5	1	2.2	3.3	1	2.4	3.3	1	3.0	2.6
	Quantities.	1.75	.39	.83	1.63	.46	.85	1.58	.51	.76	1.52	.51	.71	1.53	.68	.59

*Compiled by Prof. Duff A. Abrams of Structural Materials Research Laboratory, Lewis Institute, Chicago.

NOTE.—This table is based on a high-grade concrete which gives a strength of 3,000 pounds per square inch at 28 days. In other words, a concrete which with average well-

Gross volume of sides (from page 755)..... 368 cu. ft.

Deduct

Five 3×6 windows $= 5 \left(3 \times 6 \times \frac{8}{12} \right) = 60$ cu. ft.

One $7\frac{1}{2} \times 9$ door $= 7\frac{1}{2} \times 9 \times \frac{8}{12} = 45$ " "

Total deductions.....	105 " "	105 " "
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Net volume concrete.....	263 " "
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Total Volume of Concrete.—Adding the results obtained in the foregoing calculations, the total amount of concrete required is as follows:

For foundation and floor....272 cu. ft.

For walls263 " "

Total quantity of concrete. 535 " "

or $535 \div 27 = 20$ cu. yds.

Estimate for Materials.—The quantity of material needed to make the concrete may be estimated by the method given on page 772 of 2, or may more conveniently be obtained by aid of the table on the next page.

Concrete

In proportioning the concrete use the standard 1:2:4 mixture, that is:

NOTE.—Continued.

graded aggregates, would require a proportion of 1:2:3. For this proportion the sand would be well graded in size from fine up to $\frac{1}{4}$ -inch, and the stone from $\frac{1}{4}$ -inch up to $1\frac{1}{2}$ -inches. The use of this table principally is for determining the relative amounts of cement, sand and stone when this size of aggregate is not available. In other words, the contractor might find that there was available in the locality of the work only a rather fine sand and somewhat large, coarse aggregate; in which case, instead of the proportion being 1:2:3 it would need to be varied in order to secure the desired strength and quality. The bold-faced figures in the upper part of each square represent the proportion, while the lighter figures in the lower part of the square represent the amount in barrels and cubic yards of cement, sand and stone for the proportion given.

- 1 part cement
- 2 parts sand
- 4 parts gravel or crushed stone.

Accordingly look in the table in third line of figures for the 1:2:4 mixture and find amounts needed per cu. yd. of concrete.

- 1.51 bbls. of cement
- .45 cu. yd. of sand
- .89 cu. yd. of gravel or crushed stone.

Hence for 20 cu. yds. of concrete, being the amount as just calculated, that will be required for the building, the total quantities of materials for this amount of concrete are:

$$\begin{aligned}
 20 \times 1.51 &= 30.2 \text{ bbls. of cement} \\
 20 \times .45 &= 9 \text{ cu. yds. of sand} \\
 20 \times .89 &= 17.8 \text{ cu. yds. of gravel or crushed stone}
 \end{aligned}$$

CONCRETE

Amounts needed for One Cubic Yard

PROPORTIONS BY PARTS			Barrels of Cement	Cu. Yds. Sand	Cu. Yds. Stone or Pebbles
Cement	Sand	Stone			
1	1½	3	1.91	0.42	0.85
1	2	3	1.74	0.52	0.77
1	2	4	1.51	0.45	0.89
1	2½	4	1.39	0.51	0.82
1	2½	5	1.24	0.46	0.92
1	3	6	1.06	0.47	0.94

TO USE TABLE: Figure the number of cubic yards of mortar or concrete needed. Multiply this quantity by the figures given for the proper mix and the result will be the amount of material needed. In proportioning, one bag of cement equals one cubic foot.

Data on Mixing Concrete

Dimensions for Bottomless Measuring Boxes of Various Capacities

Capacity in Cubic Feet	Inside Measure		
	Length Inches	Breadth Inches	Height Inches
1 cubic foot.....	12	12	12
1 $\frac{1}{4}$ cubic feet.....	15	15	9 $\frac{5}{8}$
1 $\frac{1}{2}$ cubic feet.....	15	15	11 $\frac{1}{2}$
1 $\frac{3}{4}$ cubic feet.....	15	15	13 $\frac{1}{2}$
2 cubic feet.....	18	18	10 $\frac{5}{8}$
2 $\frac{1}{4}$ cubic feet.....	18	18	12
2 $\frac{1}{2}$ cubic feet.....	18	18	13 $\frac{3}{8}$
2 $\frac{3}{4}$ cubic feet.....	18	18	14 $\frac{5}{8}$
3 cubic feet.....	18	18	16

Hourly Output of Concrete for Various Proportions Based on Average Time Per Batch

Proportions, 1-Bag Batch	Aver. Time per Batch 2 Minutes	Aver. Time per Batch 3 Minutes	Aver. Time per Batch 4 Minutes
	Cubic Yds.	Cubic Yds.	Cubic Yds.
1:1 $\frac{1}{2}$:3.....	4.0	2.6	2.0
1:2:3.....	4.3	2.9	2.2
1:2:4.....	5.0	3.3	2.5
1:2 $\frac{1}{2}$:4.....	5.4	3.6	2.7
1:2 $\frac{1}{2}$:4 $\frac{1}{2}$	5.7	3.8	2.9
1:2 $\frac{1}{2}$:5.....	6.0	4.0	3.0
1:3:6.....	7.1	4.7	3.5

Computing Daily Yardage of Concrete Mixed and Placed

Proportions	Amount of Concrete in a 1-Bag Batch	
	Cubic Feet	Cubic Yards
1:1 $\frac{1}{2}$:3.....	3.53	.131
1:2:3.....	3.90	.145
1:2:3 $\frac{1}{2}$	4.22	.156
1:2:4.....	4.50	.167
1:2 $\frac{1}{2}$:4.....	4.88	.181
1:2 $\frac{1}{2}$:4 $\frac{1}{2}$	5.17	.192
1:2 $\frac{1}{2}$:5.....	5.44	.202
1:3:5.....	5.81	.215
1:3:5 $\frac{1}{2}$	6.11	.226
1:3:6.....	6.38	.236

Materials for Small Foundation Walls of Concrete

Wall 7 ft. high—Material needed for each 10 ft. length.

Thickness	1:2:4 Mixture			1:2½:5 Mixture			1:3:6 Mixture		
	Bags Cement	Cubic Feet Sand	Cubic Feet Stone	Bags Cement	Cubic Feet Sand	Cubic Feet Stone	Bags Cement	Cubic Feet Sand	Cubic Feet Stone
8 in.	10½	20¾	41½	8½	21	42	7½	22¾	44½
9 in.	11¾	23¾	46¾	9¾	23¾	47¾	8¾	25½	50¾
10 in.	12¾	25¾	51¾	10½	26¾	52½	9¾	28	56
12 in.	15¾	30¾	61¾	12¾	31½	63	11½	33¾	67¾
18 in.	23	46¾	92¾	18¾	47¾	94¾	16½	50¾	100

Wall 8 ft. high—Material needed for each 10 ft. length.

8 in.	11½	23½	47	9¾	24	48	8½	25½	51½
9 in.	13½	26¾	52¾	10½	27	54	9¾	28¾	57¾
10 in.	14¾	29¾	58¾	12	30	60	10¾	32	64
12 in.	17¾	35¾	70¾	14¾	36	72	12¾	38¾	76¾
18 in.	26¾	52¾	106	21¾	54	108	19¾	57½	115

Wall 9 ft. high—Material needed for each 10 ft. length.

8 in.	13½	26½	53	10¾	27	54	9¾	28¾	57½
9 in.	14¾	29¾	59¾	12¾	30¾	60¾	10¾	32¾	64¾
10 in.	16½	33	66	13½	33¾	67½	12	36	72
12 in.	19¾	39¾	79¾	16¾	40¾	81	14¾	43¾	86¾
18 in.	29¾	59¾	119	24¾	60¾	121	21¾	64¾	130

Material for each 10 ft. of length of Footings 1:3:6 Mixture

Size (height x width)	Cement Bags	Sand Cu. Ft.	Stone Cu. Ft.
6 in. x 12 in.....	4½	2¾	4½
7 in. x 14 in.....	1½	3¾	6½
8 in. x 16 in.....	1½	4½	8¾
9 in. x 18 in.....	1½	5½	10¾
10 in. x 20 in.....	2½	6½	13
12 in. x 24 in.....	3½	9½	18¾
15 in. x 30 in.....	5	14¾	29¾

Cost of Materials for Concrete.—The cost will of course depend on the prevailing prices in the locality where the building is to be constructed, but to illustrate the method of estimating, assume the materials delivered may be obtained at the following prices: cement, \$2.80 per barrel; sand, \$1.50 per cu. yd.; stone, \$4.00 per cu. yd. Accordingly, cost of material is :

$$30.2 \text{ bbls. cement @ } \$2.80 = 30.2 \times 2.80 = \$84.56$$

$$9 \text{ cu. yds. sand @ } \$1.50 = 9 \times 1.50 = 13.50$$

$$17.8 \text{ cu. yds. stone @ } \$4.00 = 17.8 \times 4 = 71.20$$

$$\text{Total cost of materials for concrete} = \$169.26$$

Forms.—The cost of the forms will vary with the quantity of lumber required to complete one sq. ft. of forms, and the more lumber that is required to each sq. ft. of form, the greater will be the amount of labor required handling, framing and erecting same. The cost of forms will also depend upon the number of times it is possible to use the lumber. No forms are needed for small foundations if the soil be firm. Simply dig a trench the exact size and fill the trench with the concrete, being careful not to knock earth from sides into the fresh concrete. Of course in the case of an enlargement at the bottom or footing, the form will have to extend from the top of the footing. It is customary to estimate the cost of concrete forms either by the square foot of forms or by the thousand feet of lumber, but the square foot method is more generally used. By referring to the table given on the next page, it is possible to tell just how much lumber is required to complete one square foot of forms.

Thus, look in table in third line of figure for 10 ft. ceiling (approximate distance from top of footing to top of wall) and find the value $3\frac{1}{4}$ for 8 in. wall. This means that it will require $3\frac{1}{2}$ ft. board measure of lumber to

Board Feet in Various Sizes and Lengths of Lumber
For Estimating Forms and Other Timber Work

Size of Timber in Inches	LENGTH OF PIECE IN FEET							
	10	12	14	16	18	20	22	24
1x 2	1 $\frac{2}{3}$	2	2 $\frac{1}{3}$	2 $\frac{2}{3}$	3	3 $\frac{1}{3}$	3 $\frac{2}{3}$	4
1x 3	2 $\frac{1}{2}$	3	3 $\frac{1}{2}$	4	4 $\frac{1}{2}$	5	5 $\frac{1}{2}$	6
1x 4	3 $\frac{1}{3}$	4	4 $\frac{2}{3}$	5 $\frac{1}{3}$	6	6 $\frac{2}{3}$	7 $\frac{1}{3}$	8
1x 5	4 $\frac{1}{6}$	5	5 $\frac{5}{6}$	6 $\frac{2}{3}$	7 $\frac{1}{2}$	8 $\frac{1}{3}$	9 $\frac{1}{6}$	10
1x 6	5	6	7	8	9	10	11	12
1x 8	6 $\frac{2}{3}$	8	9 $\frac{1}{3}$	10 $\frac{2}{3}$	12	13 $\frac{1}{3}$	14 $\frac{2}{3}$	16
1x10	8 $\frac{1}{3}$	10	11 $\frac{2}{3}$	13 $\frac{1}{3}$	15	16 $\frac{2}{3}$	18 $\frac{1}{3}$	20
1x12	10	12	14	16	18	20	22	24
2x 4	6 $\frac{2}{3}$	8	9 $\frac{1}{3}$	10 $\frac{2}{3}$	12	13 $\frac{1}{3}$	14 $\frac{2}{3}$	16
2x 6	10	12	14	16	18	20	22	24
2x 8	13 $\frac{1}{3}$	16	18 $\frac{2}{3}$	21 $\frac{1}{3}$	24	26 $\frac{2}{3}$	29 $\frac{1}{3}$	32
2x10	16 $\frac{2}{3}$	20	23 $\frac{1}{3}$	26 $\frac{2}{3}$	30	33 $\frac{1}{3}$	36 $\frac{2}{3}$	40
2x12	20	24	28	32	36	40	44	48
2x14	23 $\frac{1}{3}$	28	32 $\frac{2}{3}$	37 $\frac{1}{3}$	42	46 $\frac{2}{3}$	51 $\frac{1}{3}$	56
3x 4	10	12	14	16	18	20	22	24
3x 6	15	18	21	24	27	30	33	36
3x 8	20	24	28	32	36	40	44	48
3x10	25	30	35	40	45	50	55	60
3x12	30	36	42	48	54	60	66	72
3x14	35	42	49	56	63	70	77	84
4x 4	13 $\frac{1}{3}$	16	18 $\frac{2}{3}$	21 $\frac{1}{3}$	24	26 $\frac{2}{3}$	29 $\frac{1}{3}$	32
4x 6	20	24	28	32	36	40	44	48
4x 8	26 $\frac{2}{3}$	32	37 $\frac{1}{3}$	42 $\frac{2}{3}$	48	53 $\frac{1}{3}$	58 $\frac{2}{3}$	64
4x10	33 $\frac{1}{3}$	40	46 $\frac{2}{3}$	53 $\frac{1}{3}$	60	66 $\frac{2}{3}$	73 $\frac{1}{3}$	80
4x12	40	48	56	64	72	80	88	96
4x14	46 $\frac{2}{3}$	56	65 $\frac{1}{3}$	74 $\frac{2}{3}$	84	93 $\frac{1}{3}$	102 $\frac{2}{3}$	112
6x 6	30	36	42	48	54	60	66	72
6x 8	40	48	56	64	72	80	88	96
6x10	50	60	70	80	90	100	110	120
6x12	60	72	84	96	108	120	132	144
6x14	70	84	98	112	126	140	154	168
8x 8	53 $\frac{1}{3}$	64	74 $\frac{2}{3}$	85 $\frac{1}{3}$	96	106 $\frac{2}{3}$	117 $\frac{1}{3}$	128
8x10	66 $\frac{2}{3}$	80	93 $\frac{1}{3}$	106 $\frac{2}{3}$	120	133 $\frac{1}{3}$	146 $\frac{2}{3}$	160
8x12	80	96	112	128	144	160	176	192
8x14	93 $\frac{1}{3}$	112	130 $\frac{2}{3}$	149 $\frac{1}{3}$	168	186 $\frac{2}{3}$	205 $\frac{1}{3}$	224
8x16	106 $\frac{1}{2}$	128	149	170	192	213	234	256
10x10	83 $\frac{1}{3}$	100	116 $\frac{2}{3}$	133 $\frac{1}{3}$	150	166 $\frac{2}{3}$	183 $\frac{1}{3}$	200
10x12	100	120	140	160	180	200	220	240
10x14	116 $\frac{2}{3}$	140	163 $\frac{1}{3}$	186 $\frac{2}{3}$	210	233 $\frac{1}{3}$	256 $\frac{2}{3}$	280
10x16	133 $\frac{1}{3}$	160	186 $\frac{2}{3}$	213 $\frac{1}{3}$	240	266 $\frac{2}{3}$	293 $\frac{1}{3}$	320
12x12	120	144	168	192	216	240	264	288
12x14	140	168	196	224	252	280	308	336
12x16	160	192	224	256	288	320	352	384
14x14	163 $\frac{1}{3}$	196	228 $\frac{2}{3}$	261 $\frac{1}{3}$	294	326 $\frac{2}{3}$	359 $\frac{1}{3}$	392
14x16	186 $\frac{2}{3}$	224	261 $\frac{1}{3}$	298 $\frac{2}{3}$	336	373 $\frac{1}{3}$	410 $\frac{2}{3}$	448

complete one sq. ft. of form. Now suppose the wall be built with three pourings of the concrete; this will require the forms to extend one-third the height of wall or $\frac{1}{3}$ of 10 = $3\frac{1}{3}$ ft. and the sq. ft. of surface all around the garage this height is

$$3\frac{1}{3}(2 \times 20 + 2 \times 10\frac{2}{3}) = 204 \text{ sq. ft.}$$

for which amount of lumber required is

$$204 \times 3\frac{1}{3} = 680 \text{ ft. board measure}$$

Cost of lumber

$$680 \text{ ft. hemlock @ } \$55 = \frac{680}{1,000} \times 55 = \$37.40$$

2. Labor

Forms.—Assuming for work of this character that a carpenter and laborer will handle, frame and erect 100 ft. of lumber an hour, time required to erect one zone of the form is

$$680 \div 100 = 6.8 \text{ hours}$$

allowing additional time for placing form in successive positions for 2nd and 3rd zones, call total time on forms say 10 hrs.

Cost of Labor on Forms.—On basis of 90c. per hour.

$$\text{Cost of making and placing forms} = 10 \times .90 = \$9.00$$

Cost of Mixing and Placing Concrete.—Where the concrete is mixed by hand with only one mixing board being used, and in instances where the concrete is shoveled directly from the mixing board into the forms or trenches.

It will require from $3\frac{1}{4}$ to $3\frac{1}{2}$ hours' labor time for one man to mix and deposit one cu. yd. of concrete. If it should be necessary to load the concrete into barrows and wheel same to point of deposit, it will require 4 to $4\frac{1}{4}$ hours' time for one man to mix and deposit one cu. yd. of concrete.

Now, as found, it requires 20 cu. yds. of concrete for the building, and on a basis of say 4 hours' time per cu. yd. to mix and place the concrete,

$$\text{labor, mixing and placing} = 20 \times 4 = 80 \text{ hours}$$

and on a basis of 90c. per hour for labor,

$$\text{Cost of mixing and placing concrete} = .90 \times 80 = \$72.$$

Cost of Stripping.—A laborer should remove or strip from 125 to 150 ft. of lumber per hour. Now as found there were 663 ft. of forms per zone, and for three zones total number to be stripped is

$$680 \times 3 = 2,040 \text{ ft.}$$

and on a basis of 125 ft. per hour,

$$\text{labor stripping} = 2,040 \div 125 = 16 \text{ hours}$$

$$\text{Cost of stripping @ 90c. per hr.} = 16 \times .90 = \$14.40$$

Summary of Cost

Materials.

Forms.....	\$ 37.40
Concrete.....	169.26

Labor.

Forms { making	9.00
{ stripping	14.40
Concrete.....	72.00

Total cost concrete construction.....\$302.06

Atlas Table for Concrete Materials.—With the following table, the quantities of each material needed for any job are quickly figured.

The first column shows the quantity of concrete. The other five divisions show the different mixtures and quantities of materials under each mixture needed to produce quantity of concrete given in first section.

Example —Determine amount of materials for 291 cubic feet of 1:2:4 mixture. Look in the columns headed "1:2:4 mixture," copy out the figures for 100 cubic feet and multiply them by two, to make 200. This gives 44 bags cement 88 cubic feet of sand and 176 of stone. Then look under the same head, opposite 90 cubic feet: $19 \frac{4}{5}$ bags cement, $39 \frac{3}{5}$ cubic feet sand

Atlas Table for Determining Quantity of Materials

Cubic feet of concrete	1 : 1½ : 3 Mixture			1 : 2 : 3 Mixture			1 : 2 : 4 Mixture			1 : 2½ : 5 Mixture			1 : 3 : 6 Mixture		
	Bags Cement	Cubic feet Sand	Cubic feet Stone	Bags Cement	Cubic feet Sand	Cubic feet Stone	Bags Cement	Cubic feet Sand	Cubic feet Stone	Bags Cement	Cubic feet Sand	Cubic feet Stone	Bags Cement	Cubic feet Sand	Cubic feet Stone
100	28	42	84	25 4/5	51 3/5	77 2/5	22	44	88	18	45	90	16	48	96
90	25 1/5	37 4/5	75 3/5	23 1/5	46 2/5	69 3/5	19 4/5	39 3/5	79 1/5	16 1/5	40 1/2	81	14 2/5	43 1/5	86 2/5
80	22 2/5	33 3/5	67 1/5	20 2/3	41 1/3	62	17 3/5	35 1/5	70 2/5	14 2/5	36	72	12 4/5	38 2/5	76 4/5
70	19 3/5	29 2/5	58 4/5	18	36	54	15 2/5	30 4/5	61 3/5	12 3/5	31 1/2	63	11 1/5	33 3/5	67 1/5
60	16 4/5	25 1/5	50 2/5	15 1/2	31	46 1/2	13 1/5	26 2/5	52 4/5	10 4/5	27	54	9 3/5	28 4/5	57 3/5
50	14	21	42	13	26	39	11	22	44	9	22 1/2	45	8	24	48
40	11 1/5	16 4/5	33 3/5	10 1/3	20 2/3	31	8 4/5	17 3/5	37 1/5	7 1/5	18	36	6 2/5	19 1/5	38 2/5
30	8 2/5	12 3/5	25 1/5	7 3/4	15 1/2	23 1/4	6 3/5	13 1/5	26 2/5	5 2/5	13 1/2	27	4 4/5	14 2/5	28 4/5
20	5 3/5	8 2/5	16 4/5	5 1/5	10 2/5	15 3/5	4 2/5	8 4/5	17 3/5	3 3/5	9	18	3 1/5	9 3/5	19 1/5
10	2 4/5	4 1/5	8 2/5	2 3/5	5 1/5	7 4/5	2 1/5	4 2/5	8 4/5	1 4/5	4 1/2	9	1 3/5	4 4/5	9 3/5
9	2 1/2	3 4/5	7 3/5	2 1/3	4 2/3	7	2	4	8	1 3/5	4	8	1 1/2	4 1/3	8 2/3
8	2 1/4	3 3/8	6 3/4	2	4 1/6	6 1/4	1 3/4	3 1/2	7	1 2/5	3 3/5	7 1/5	1 1/4	3 7/8	7 3/4
7	2	3	6	1 4/5	3 1/2	5 2/5	1 1/2	3	6	1 1/4	3 1/8	6 1/4	1 1/8	3 3/8	6 3/4
6	1 2/3	2 1/2	5	1 3/5	3 1/5	4 3/5	1 1/3	2 2/3	5 1/3	1 1/10	2 3/4	5 1/2	1	3	6
5	1 2/5	2 1/10	4 1/5	1 1/3	2 2/3	4	1 1/10	2 1/5	4 2/5	9/10	2 1/4	4 1/2	4/5	2 2/5	4 4/5
4	1 1/8	1 3/4	3 3/8	1	2	3 1/5	7/8	1 3/4	3 1/2	7/10	1 4/5	3 3/5	5/8	2	4
3	4/5	1 1/4	2 1/2	3/4	1 1/2	2 1/3	2/3	1 1/3	2 2/3	1/2	1 1/3	2 2/3	1/2	1 1/2	3
2	9/16	7/8	1 11/16	1/2	1	1 1/2	7/16	7/8	1 3/4	1/3	9/10	1 4/5	5/16	1	2
1	9/32	7/16	7/8	1/4	1/2	3/4	7/32	7/16	7/8	1/5	1/20	1	5/32	1/2	1

NOTE.—*In building a square tank* or a room or anything hollow for which the proportioning of materials is the same in all its parts. Figure on the whole thing as if it were solid and then subtract the volume of the hollow part in the center. For instance, find out the number of cu. ft. of concrete needed for a tank 10 ft. long and 10 ft. wide and 8 ft. high with walls, floor and roof all 6 ins. thick, by calculating first the volume of the whole thing as if it were solid. That would be $10 \times 10 \times 8$, or 800 cu. ft. Then figure the volume of the hollow inside. Allowing for the 6 in. walls, the inside measurements will be 9 ft. long, 9 ft. wide and 7 ft. high. So the volume of the hollow part will be $9 \times 9 \times 7$, or 567 cu. ft. The number of cu. ft. in the walls, floor and roof will be the difference between 800 and 567 or 233 cu. ft.

NOTE.—*To calculate* for anything circular there is one rule to remember: the area of a circle is found by multiplying the diameter by the diameter, then multiplying the result by $3/7$ and dividing by 4. So that a circular slab of concrete 7 ft. in diameter would have an area 7 times 7, $3/7$, divided by 4, that is $38\frac{1}{2}$ sq. ft. Multiply this area by the thickness in ft. or fraction of a ft. and obtain the number of cu. ft. in the slab. If this slab be 6 ins. thick, the number of cu. ft. in it will be $38\frac{1}{2}$ multiplied by $\frac{1}{2}$, or $19\frac{1}{4}$.

NOTE.—*In building a circular tank*, figure the total volume as if it were solid. Then calculate the volume of the hollow space that is not to be filled with concrete and subtract this from the first total.

and $79\frac{1}{5}$ cubic feet stone. Then look opposite 1 cubic foot and you find $7\frac{1}{32}$ bag cement, $7\frac{1}{16}$ cubic foot sand and $7\frac{1}{8}$ cubic foot sand and gravel. Add these three and find that for 291 cubic feet of concrete in 1:2:4 mixture, will need 64 bags cement, 128 cubic feet sand and 256 cubic feet stone or gravel.

Quantities for Mortar and Concrete*

(From "Concrete Plain and Reinforced," by Taylor & Thompson)

MORTAR

Amounts needed for One Cubic Yard

PROPORTIONS BY PARTS		Barrels of Cement	Cubic Yards Sand
Cement	Sand		
1	0	8.31	
1	1	4.88	0.72
1	1½	3.87	0.86
1	2	3.21	0.95
1	2½	2.74	1.01
1	3	2.39	1.06
1		1.90	1.13

Concrete Building Block and Clay Tile

	†Number of Brick Equivalent to	Cement for Laying 1000 1:3 Mortar	Sand for Laying 1000 1:3 Mortar	Number of Block to 100 Sq. Ft. of wall surface
Concrete Block 8 x 8 x 16...	12	†	†	112
Concrete Block 8 x 8 x 24...	18	†	†	75
Clay Tile 3x 12 x 12.....	5	4¾ bbls.	2.1 cu. yds.	100
Clay Tile 6 x 12 x 12.....	10	6½ bbls.	2.9 cu. yds.	100
Clay Tile 12 x 12 x 12.....	20	7½ bbls.	3.3 cu. yds.	100

†No accurate data available. Probably safe to assume slightly larger quantities than given for equivalent clay tile.

Covering Capacity of Mortar and Stucco

Area covered by one barrel of Cement in various mixes

MIX Parts by Volume		THICKNESS OF COAT				
		¼ Inch	⅓ Inch	½ Inch	¾ Inch	1 Inch
Cement	Sand	Sq. Ft.	Sq. Ft.	Sq. Ft.	Sq. Ft.	Sq. Ft.
1	1	266	177	133	89	66
1	1½	336	226	168	112	84
1	2	404	270	202	135	101
1	2½	472	314	236	157	118
*1	3	542	362	271	181	136
1	3½	612	408	306	204	153
1	4	682	455	341	227	171

Area covered by one Cubic Yard of Sand in Various Mixes

MIX Parts by Volume		THICKNESS OF COAT				
		¼ Inch	⅓ Inch	½ Inch	¾ Inch	1 Inch
Cement	Sand	Sq. Ft.	Sq. Ft.	Sq. Ft.	Sq. Ft.	Sq. Ft.
1	1	1800	1200	900	600	450
1	1½	1508	1006	754	503	377
1	2	1364	910	682	455	341
1	2½	1282	855	641	427	321
*1	3	1222	815	611	407	306
1	3½	1178	785	589	393	294
1	4	1148	765	574	383	287

*1 : 3 is the mix most used for stucco work.

HOW TO USE THE TABLE: Figure the wall area in square feet. Divide this area by the proper number in the tables above and the result will be the number of barrels of cement required or the number of cubic yards of sand.

NOTE: The above areas are calculated for average sand and with no allowance for waste. In estimating, allowance should be made for waste. When figured for stucco, the loss of mortar in forming the keys behind the lath for the first coat should be taken into account.



Table of Quantities for Curbs and Gutters for Each 100 Feet of Length

FIG. 5,281.—Section of separate curb.

SEPARATE CURB

A Ins.	B Ins.	C Ins.	1:2:3 Mix*			1:2:4 Mix			1:2 1/2:5 Mix		
			Cement bbls.	Sand cu. yds.	Stone cu. yds.	Cement bbls.	Sand cu. yds.	Stone cu. yds.	Cement bbls.	Sand cu. yds.	Stone cu. yds.
24	6	8	7.50	2.25	3.34	6.50	1.95	3.86	5.37	2.00	3.98
30	6	8 1/2	9.73	2.91	4.31	8.45	2.52	4.99	6.94	2.58	5.15
36	6	9	12.10	3.61	5.35	10.50	3.12	6.18	8.61	3.19	6.39



FIG. 5,282.—Section of integral curb.

INTEGRAL CURB

A Ins.	B Ins.	C Ins.	1:1 1/2:3 Mix			1:2:3 Mix*			1:2:4 Mix		
			Cement bbls.	Sand cu. yds.	Stone cu. yds.	Cement bbls.	Sand cu. yds.	Stone cu. yds.	Cement bbls.	Sand cu. yds.	Stone cu. yds.
6	6	7	1.91	0.42	0.85	1.74	0.52	0.77	1.51	0.45	0.89

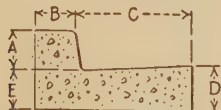


FIG. 5,283.—Section of combined curb and gutter.

COMBINED CURB AND GUTTER

A Ins.	B Ins.	C Ins.	D Ins.	E Ins.	1:2:3 Mix*			1:2:4 Mix			1:2 1/2:5 Mix		
					Cement bbls.	Sand cu. yds.	Stone cu. yds.	Cement bbls.	Sand cu. yds.	Stone cu. yds.	Cement bbls.	Sand cu. yds.	Stone cu. yds.
6	6	18	7	6	8.70	2.60	3.85	7.55	2.25	4.45	6.20	2.30	4.60
6	6	24	7 1/2	6	10.80	3.22	4.77	9.35	2.79	5.52	7.68	2.85	5.70

*A 1:2:3 mix is much used for curb work, especially where no plastering of the surface is allowed.

†The leaner 1:2 1/2:5 mix is generally employed for curbs which will be finished by a mortar plaster coat. This practice is now not favored by many persons, but where it is allowed an additional allowance should be in the estimate for the cement used in the plastered coat.

Quantities for 100 Concrete Fence Posts

Square Section—1:2:3 Mix

Size			Cement	Sand	Stone or Pebbles	Reinforcement
Top	Bottom	Length	Bbls.	Cu. Yds.	Cu. Yds.	4 bars
3 in. sq.	5 in. sq.	6 ft. 6 in.	4.9	1.5	2.2	¼ in.— 433 lbs
4 in. sq.	5 in. sq.	7 ft. 6 in.	6.9	2.1	3.0	¼ in.— 500 lbs
4 in. sq.	6 in. sq.	8 ft. 0 in.	9.3	2.8	4.1	¾ in.—1200 lbs

*Quantities for Concrete Silos—6-in. Walls

1: 2: 4 Walls and 1:2½:5 Floor and Footings; without Roof

Size Diameter x Height	Cement Bbls.	Sand Cu. Yds.	Stone or Pebbles Cu. Yds.
10 x 25 ft.	25 0	7.5	15.0
12 x 30 ft.	36.0	11.0	22.0
12 x 35 ft.	41.0	12.5	25.0
14 x 30 ft.	42.5	13.0	26.0
14 x 35 ft.	48.0	14.7	29.4
14 x 40 ft.	54.5	16.5	33.0
16 x 40 ft.	62.5	19.0	38.0
16 x 45 ft.	69.0	21 0	42.0
18 x 45 ft.	80.0	24.5	49.0
18 x 50 ft.	86.5	26 5	53.0

*These quantities are approximate and intended for rough preliminary estimates.

Quantities for One-Course Sidewalks and Floors

100 Square Feet of Surface

Thickness	Cubic Yards of Concrete per 100 Sq. Ft.	1:2:3 Mix			1:2:4 Mix		
		Cement Bbls.	Sand Cu. Yds.	Stone Cu. Yds.	Cement Bbls.	Sand Cu. Yds.	Stone Cu. Yds.
3 in.	0.93	1.62	0.48	0.72	1.41	0.42	0.83
3½ "	1.03	1.88	0.56	0.83	1.63	0.49	0.96
4 "	1.22	2.14	0.63	0.94	1.84	0.55	1.09
4½ "	1.39	2.42	0.72	1.07	2.10	0.62	1.23
5 "	1.54	2.68	0.80	1.18	2.33	0.69	1.37
5½ "	1.70	2.96	0.88	1.31	2.56	0.76	1.51
6 "	1.85	3.22	0.96	1.42	2.79	0.83	1.64

Quantities for Two-Course Sidewalks and Floors

100 Square Feet of Surface

Thickness	Base Course					
	1:2½:5 Mix			1:3:6 Mix		
	Cement Bbls.	Sand Cu. Yds.	Stone Cu. Yds.	Cement Bbls.	Sand Cu. Yds.	Stone Cu. Yds.
3 in.	1.15	0.43	0.85	0.98	0.43	0.87
3½ "	1.34	0.50	0.99	1.15	0.51	1.02
4 "	1.51	0.56	1.12	1.29	0.56	1.12
4½ "	1.72	0.64	1.28	1.47	0.65	1.31
5 "	1.91	0.71	1.42	1.63	0.72	1.44

Thickness	Top Course					
	1:1 Mix		1:1½ Mix		1:2 Mix	
	Cement Bbls.	Sand Cu. Yds.	Cement Bbls.	Sand Cu. Yds.	Cement Bbls.	Sand Cu. Yds.
½ in.	0.75	0.11	0.60	0.13	0.50	0.15
¾ "	1.13	0.17	0.90	0.20	0.75	0.22
1 "	1.50	0.22	1.20	0.27	1.00	0.29

Quantities for Concrete Roads and Pavements

Width in Feet	Square Yards per Mile	Thickness		Cubic Yards Concrete per Linear Foot of Pavement	Material Required per Linear Foot of Pavement—1:2:3 Mix*		
		Sides, Inches	Center, Inches		Cement Barrels	Sand Cubic Yards	Stone or Pebbles Cubic Yards
9	5,280	6	8	.204	.355	.106	.157
10	5,867	6	8	.227	.394	.118	.175
16	9,387	6	8	.362	.630	.188	.279
16	"	7	9	.411	.715	.214	.316
16	"	8	10	.461	.802	.240	.355
18	10,560	6	8	.407	.708	.212	.313
18	"	7	9	.463	.806	.241	.357
18	"	8	10	.519	.903	.270	.400
20	11,733	6	8	.453	.788	.235	.349
20	"	7	9	.514	.887	.265	.393
20	"	8	10	.576	1.002	.300	.444
24	14,080	6	8	.543	.945	.282	.418
24	"	7	9	.617	1.074	.321	.475
24	"	8	10	.691	1.202	.359	.532

Quantities for 1000 Square Yards Concrete Base for Pavements UNIFORM THICKNESS THROUGHOUT

Thickness of Base	Cubic Yards of Concrete per 1,000 Sq. Yds. of Pavement	MIX*								
		1:2:4			1:2½:5			1:3:6		
		Cement Bbls.	Sand Cu. Yds.	Stone Cu. Yds.	Cement Bbls.	Sand Cu. Yds.	Stone Cu. Yds.	Cement Bbls.	Sand Cu. Yds.	Stone Cu. Yds.
5 in.	139	210	62	124	172	64	128	147	65	135
6 "	167	252	75	149	206	77	153	177	78	157
7 "	194	294	87	173	241	89	179	206	91	183
8 "	222	335	100	198	275	104	204	235	104	209

Quantities for 1000 Square Yards Concrete Roads and Pavements CROWNED SURFACE

Thickness		Average Thickness	Cu. Yds. of Concrete per 1,000 Sq. Yds. of Pavement	MIX*								
				1:1½:3			1:2:3			1:2:4		
Sides	Center			Cement Bbls.	Sand Cu. Yds.	Stone Cu. Yds.	Cement Bbls.	Sand Cu. Yds.	Stone Cu. Yds.	Cement Bbls.	Sand Cu. Yds.	Stone Cu. Yds.
5 in.	7 in.	6.33 in.	176	336	74	150	306	91	136	266	79	157
5 "	7½ "	6.67 "	185	353	78	157	322	96	143	279	83	165
6 "	8 "	7.33 "	204	389	86	174	355	106	157	308	91	182
6 "	8½ "	7.67 "	213	406	89	181	370	111	164	321	95	190
7 "	9 "	8.33 "	231	441	97	196	402	120	178	348	103	206
7 "	9½ "	8.67 "	241	460	101	205	420	125	186	364	109	215
8 "	10 "	9.33 "	259	495	109	220	450	135	200	391	116	231
8 "	10½ "	9.67 "	269	514	113	229	468	140	207	406	120	240

Table
Styles and Weights of Metal Lath for Stucco
EXPANDED METAL LATH

Name of Manufacturer	Style or Number	Gauge and Weight per Sq. Yd.	Details
The Berger Mfg. Co. Canton, Ohio	B B Diamond Mesh	26 gauge 2.5 lbs.	Painted, Galvanized or Tension Metal, not self-furring
	Standard Diamond Mesh	24 gauge 3.4 lbs.	Same
	26 gauge 2.20 lbs.	Same	Same
	3/8-inch Ribplex	24 gauge 3.4 lbs.	Same, self-furring
		26 gauge 3.06 lbs.	Same, self-furring
Youngstown-Pressed Steel Co. Warren, Ohio	No. 22 Zee Lath.	22 gauge 3.4 lbs.	Galvanized or painted, self-furring
	No. 22 Mahoning	Same	Same, not self-furring
	No. 24 Ideal	24 gauge 4.0 lbs.	Painted, not self-furring
Consolidated Exp. Metal Cos. Braddock, Pa.	24 F Rid-Gid	24 gauge 3.4 lbs.	Galvanized or painted, self-furring
Northwestern Expanded Metal Co., Chicago, Ill.	Kno-Burn	24 gauge 3.4 lbs.	Painted or galvanized, self-furring
	Corrugated Kno-Fur Regular	24 gauge 3.7 lbs.	Painted. Copper bearing metal Self-furring
The Botwick Steel Lath Co. Niles, Ohio	"Truss-Loop"	4.5 to 6.0 lbs.	Special shape. Painted, galvanized or copper-bearing
	Botwick Expanded "Diamond A."	2.2 to 4.0 lbs.	Various styles and meshes
	"Niles," "Lock," "Trumbull"		"Trumbull" self-furring
The General Fireproofing Co. Youngstown, Ohio	B B Herringbone	24 gauge 3.37 lbs.	Galvanized or painted, self-furring
Truscon Steel Co., Youngstown, Ohio	3/8-inch Hy-Rib	28, 26, 24 gauge 3, 3.6, 4.8 lbs.	Copper bearing and plain painted, self-furring
	1-A lath	3.2 lbs.	Same, not self-furring
	Truscon Diamon	27 to 22 gauge 2.33 to 4.20 lbs.	Galvanized, copper bearing, and plain steel. Not self-furring
Corrugated Bar Co., Inc., Buffalo, N. Y.	5/16-inch ribbed Cort-Mesh	24, 26, 28 gauge 5.58, 4.23, 3.51 lbs.	Galvanized or painted Self-furring

WIRE LATH

The New Jersey Wire Cloth Co., Trenton, N. J.	20-6V-G	2 1/4 inch mesh No. 20 wire	Galvanized or painted. Woven with 3/8-inch metal ribs.
	20-O-G	Same	Self-furring Same without ribs. Not self-furring
Wickwire-Spencer Steel Corp., Buffalo, N. Y., and Worcester, Mass.	"Clinton" Wire Lath	2 1/2 inch mesh No. 19 wire 3.2 lbs	Galvanized or painted. Not self-furring
	"Clinton" Wire Lath	2 1/2 inch mesh No. 20 wire 3.8 lbs.	Galvanized or painted. V stiffened self-furring
	"Clinton" Welded sheathing	No. 13 and 19 gauge wires	Special type; combination of galvanized welded wire fabric and water-proof felt; not self-furring
American Steel & Wire Co., 30 Church Street, New York	2-L triangle mesh stucco reinforcement	No. 12 and 14 wires 2.84 lbs.	Galvanized, self-furring

Explanatory Note: This table is not intended to give complete information on the various styles of metal lath. For complete details and full information it is advisable to communicate directly with the manufacturer. Expanded metal lath is generally sold in sheets packed in bundles. Wire lath usually is sold in rolls.

